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A PHYTOSOCIOLOGICAL ANALYSIS OF FORESTS, FUELS AND FIRE IN THE MOOSE CREEK DRAINAGE, SELWAY-BITTERROOT WILDERNESS

1973

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Prologue

"Unique as we may think we are, it seems likely that we are genetically programmed to a natural habitat of clean air and a varied green landscape, like any other mammal.

"The rapidly expanding work on electroencephalography in relation to stimuli is providing evidence of a need for frequent change in the environment for at least short periods, or more specifically, for qualities of diversity in it.

"One wonders what the stimuli of brick and asphalt jungles, or the monotony of corn fields, do to the nervous system. Biotic as well as cultural diversity, from a neurological point of view, may well be fundamental to the general health that figures prominently in the discussions of environmental quality."

1970

H.H. Iltis
O.L. Loucks
P. Andrews

Preface

This report, emphasizing the phytosociology of the western redcedar (Thuja plicata) and grand fir (Abies grandis) forest communities in the Moose Creek drainage of the Selway-Bitterroot Wilderness, is based on studies conducted during the summer of 1972. The research was support by a $3,500 research contract (#26-2952) between the University of Montana Foundation and the USDA Forest Service (Region 1), Missoula. Additional funding for this project ($780) was provided by the Research Advisory Council of the University of Montana.

Excellent cooperation existed between myself and many members of the USDA Forest Service, particularly with those associated with the Nez Perce National Forest. I extend my thanks to Mr. David Aldrich, contract officer for this project, and to Mr. Robert Mutch, Northern Forest Fire Laboratory, for their help and encouragement.

I also wish to acknowledge the great help provided by Drs. Robert Pfister and Stephen Arno, and Mr. Bernard Kovalchik, of the Forestry Sciences Laboratory, Missoula, in their analysis of the forest compositional data, and habitat typing of my stands. Dr. James K. Brown, Northern Forest Fire Laboratory was instrumental in the analysis of fuel accumulations and fire potentials.

The Moose Creek Ranger Station personnel are thanked for their help too; Mr. Richard Walker, Mr. Emil Keck, and Mr. Gary Koehler and other wilderness rangers and employees provided considerable beneficial help during various phases of this work. Mr. Rick Oberheu and Mr. Ron Milam composed the fuel measurement team that collected the fuel data reported on in this study.

Throughout all phases of this research, my convictions have been strengthened concerning the idea that fire has and should continue to play a basic role in wilderness ecosystem maintenance. Fire does spell disaster for individual plants and animals, at times, but fire appears to be emerging as a necessary factor in the well-being of species populations and biotic communities. What is presented in this report only touches the surfaces of the multiplicity of interactions between fire and ecosystems in this wilderness.

J.R.H., April, 1973

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Introduction

Two of the current wilderness management objectives in the Selway-Bitterroot Wilderness are (1) the determination of the natural roles of wildfire in the forest communities of this area, and (2) the determination of suitable means of returning to wildfire at least some of these natural functions (Habeck 1972). The pursuit of these objectives requires the development of a detailed description of the interrelationships between forest community composition, distribution and development, and organic fuel production and accumulation.

Wildfire is suspected of playing a critical ecological role as a "decomposer" of organic matter in the North Rocky Mountain coniferous forests (Habeck and Mutch 1973), and consequently of great importance in ecosystem stability. Modern fire suppression activities, implemented with ever-increasing effectiveness over the past 50-60 years, may well have induced a major change or alteration in the cycling of ecosystem materials through a significant modification of the decomposer role of wildfire.

It has been generally observed that as forest ecosystems initiate re-establishment following major disturbance, such as a forest fire, (=secondary succession) there is a gradual increment of accumulated biomass. Net community productivity is maximized during intermediate stages of forest ecosystem development, and displays a marked reduction

during later stages of stand development (climax).

Within the Selway-Bitterroot Wilderness. a wide range of environmental conditions exist. Landscape topography is highly varied, and steep moisture and elevational gradients are exhibited. This environmental mosaic provides a matrix within which a wide variety of forest community types exist (Habeck 1972). Grasslands and ponderosa pine (Pinus ponderosa) savannah represent the community types found on the warmest and driest habitats. Communities dominated by Douglas fir (Pseudotsuga menziesii) or mixtures of Douglas fir and grand fir (Abies grandis) occur in the mesic habitats found at low and intermediate elevations. Western redcedar (Thuja plicata), occurring in various combinations with grand fir and/or Engelmann spruce (Picea engelmannii), is found in streamside and ravine habitats throughout much of the wilderness area. At elevations above 6000 feet, subalpine fir (Abies lasiocarpa), Engelmann spruce, lodgepole pine (Pinus contorta), white bark pine (Pinus albicaulis) and alpine larch (Larix lyallii), in a wide assortment of mixtures, form the major forest cover.

Fires have affected all of the wilderness forests, and it is generally not a difficult task to detect the varied patterns of forest development induced by the multiplicity of past fires. Such patternization is best observed through aerial observation, but is clearly evident to anyone hiking through this wilderness. Immense brushfields cover portions of the area, where past fire has not been successfully followed by tree invasion. Only a small percentage of the upland, well-drained slopes are currently vegetated by old-growth forest types. Perhaps the best array of mature or nearly mature forest community types to be found occur along the Moose Creek drainage, but even along this stream system vegetational

diversity is not absent.

All of the forest zones and forest community types in the Selway-Bitterroot Wilderness are in need of detailed attention by forest and fire ecologists. Forest re-establishment and successional development following fire is greatly influenced by physical factors such as moisture, elevation and exposure, and by biotic factors, and a total assessment of the interrelationships between ecosystem structure and fuel production and accumulation require field data from all portions of the vegetation/environment complex.

The study reported upon here concentrates on only a portion of the total complex. During the summer of 1972, special attention was directed towards the western redcedar-grand fir communities located in the central portion of the Selway-Bitterroot Wilderness (Fig. 1). These communities present an interesting array of variation in their composition, distribution, and development. As a result of their occupancy on the more moist streamside habitats, many have been exempt from recent fire. Stands that are many centuries in age are common. Unlike the upland, mountain slope forests, pioneer and early seral types occur with less frequency along such streams as Moose Creek, where these studies were concentrated.

Although the oldest-aged redcedar-grand fir communities have successfully escaped major fire disturbance for long periods of time, the probability of them continuing in this condition for additional long periods of time is likely becoming reduced. Since evidence of past fire has been witnessed in all of the cedar-grand fir stands studied, the probability of them burning again is approaching a certainty.

As will be pointed out in greater detail, the basic study plan was

modified to give some attention to community types other than those dominated by western redcedar and grand fir. For comparison purposes communities in adjacent areas, currently dominated by mixtures of Douglas fir and ponderosa pine, were also given some attention. For other reasons, to be explained, a series of cedar-grand fir forests were studied in the Lochsa River drainage, north of the wilderness boundary.

General Description

A rather detailed description of the Selway-Bitterroot Wilderness has already been presented in an earlier report (Habeck 1972), but a summary overview can be outlined here. A major portion of the 1.2 million acre wilderness is drained by the Selway River, which in turn drains into the Clearwater River system of the Columbia River. Much of the area is extremely mountainous, with local relief between valley/canyon bottoms and adjacent ridges and peaks often amounting to 3000 to 4000 feet.

Much of the wilderness receives 40 or more inches of precipitation annually, with the highest elvations typically receiving 60 inches or more (much in the form of winter and early spring snowfall). The stream side elevations, associated with the Selway River and Moose Creek, receive between 45 and 50 inches annually, with the greater amounts occurring in the upper reaches of these drainages. These amounts are equal or greater than received on the western side of Glacier Park where cedar-western hemlock (Tsuga heterophylla) forests are well developed.

Rather distinct temperature gradients exist in this wilderness, and these appear to be closely correlated with intrawilderness elevational

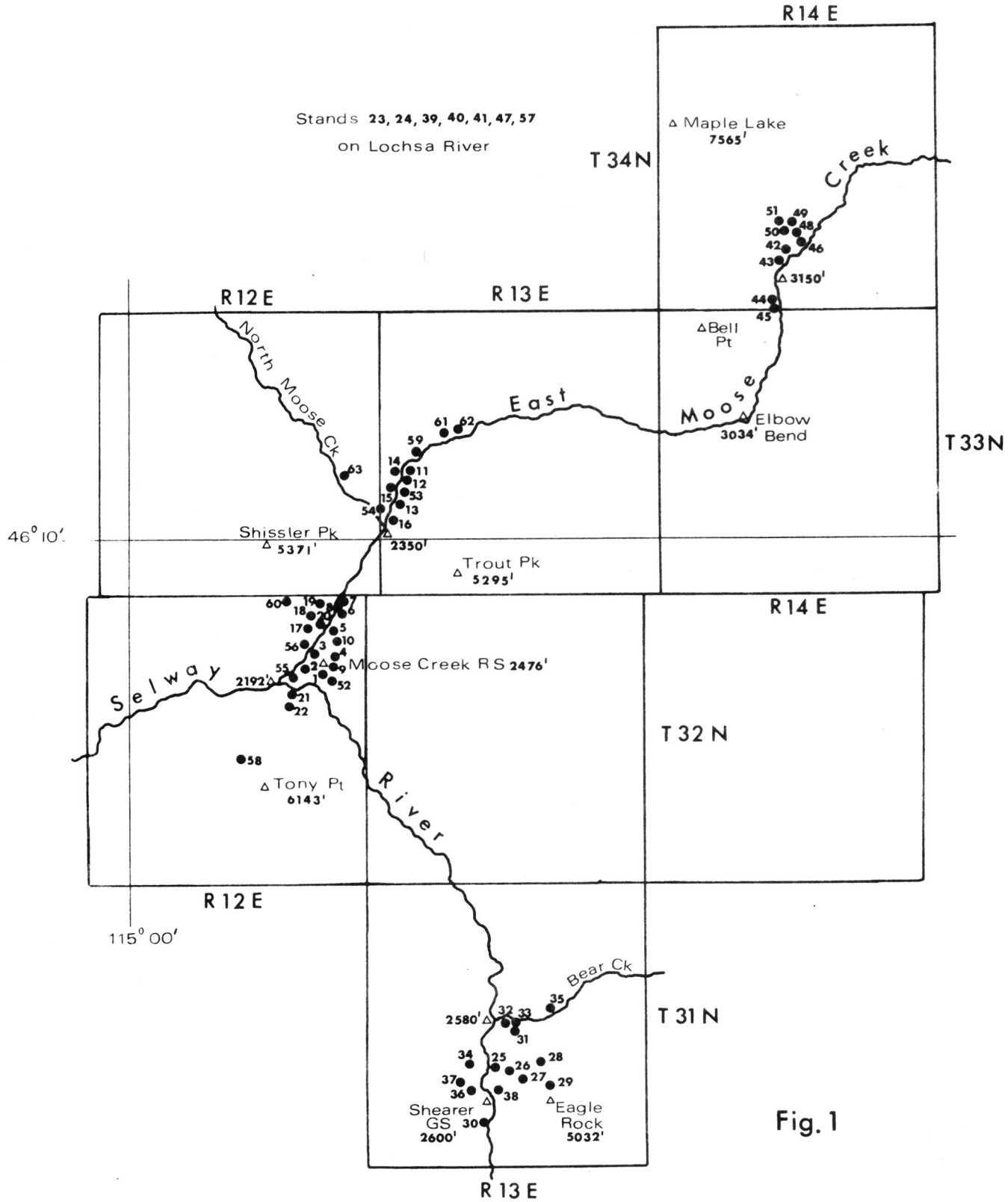
R14 E
Stands 23, 24, 39, 40, 41, 47, 57
on Lochsa River
Maple Lake
7565'
T 34N
Creek
3150'
R12 E
R13 E
Bell Pt
North Moose Ck
East
Moose
Elbow Bend
3034'
T33N
46° 10'
Shissler Pk
5371'
2350'
Trout Pk
5295'
R14 E
Moose Creek RS 2476'
2192'
Selway
T 32 N
Tony Pt
6143'
River
R12 E
115° 00'
Bear Ck
2580'
T 31 N
Shearer GS
2600'
Eagle Rock
5032'
R13 E

Fig. 1

differences. The coolest summer temperatures are experienced in the highest parts of the Bitterroot Mountains on the eastern edge of the wilderness (9000-10,000 feet). The July-August temperatures at these high elevations are generally less than 60^{o}F, and are known to approach closer to 50^{o} F near the upper timberline (Arno and Habeck 1972). Further westward, the average mid-summer temperatures increase to $70\text{-}71^{o}$ F, but these are achieved at elevations near 2000 feet on the west edge of the wilderness. Winter temperatures are also lowest in the Bitterroot Mountains, averaging 20^{o} F or less. The lower, western edge areas have January averages near 28^{o} F.

The deep, canyon-like valleys in the central portion of the wilderness are major landscape features surrounding the study area. It is perhaps by geological chance factors that the terrain immediately adjacent to the lower Moose Creek drainage is composed of a broader, bottomland "flats" than is typically present along much of the larger Selway River course. This is of significance when related to the amount of streamside habitat available for cedar-grand fir forest develoment.

The geological history of the region began, according to Lindgren (1904), with the deposition of pre-Cambian sediments and lavas. These materials were uplifted and subjected to erosion prior to the beginning of the Cenozoic. A second uplifiting occurred, raising the eroded surface to the present level of the Clearwater Plateau. The deep canyons dissecting the region were mostly excavated before the eruption of the Columbia River basalt.

Information on Study Stand Locations

The distribution of the study areas is provided in Fig. 1. A third

of the total stands sampled are located in the vicinity of the Moose Creek Ranger Station (2476 ft) and the lower reaches of Moose Creek (2190 to 2250 ft.). This segment of the samples includes a great diversity of habitats, ranging from wet, streamside sites to well-drained upland slopes. A group of fourteen stands was sampled in the area around Shearer Guard Station (2600 ft) further up the Selway River, and in the vicinity of the confluence of the Selway River and Bear Creek (2580 ft.). Again a diversity of upland and streamside forest communities was sampled here.

Eleven of the 63 stands sampled were from the region designated as the Moose Creek Ranches area, just northeast of the confluence of the North Moose Creek and East Moose Creek (2350 ft.). All of these stands were positioned on level, streamside (or nearby) sites, and included some that had developed since being destroyed or disturbed by fires in 1910. A fourth group of nine communities was sampled in the upper East Moose Creek region (3150-3250 ft) near Cedar Creek. Although this group includesseveral somewhat young, developing forests, the majority consisted of old-aged redcedar grove communities.

A total of 56 stands was studied on the Selway River, Moose Creek and Bear Creek drainages; the majority composed of various proportions and various ages of western redcedar and grand fir. For purposes of phytosociological comparison, seven cedar-grand fir communities were sampled along the Lochsa River. Six of these are located in the vicinity of the Powell Ranger Station (3400 ft) and the nearby DeVoto Memorial Cedar Grove (3580 ft.). A single stand of cedar-grand fir was sampled at the Green Flat Camground along a lower portion of the Lochsa River (2400 ft).

The phytosociological analysis included in this report is based on the 63 stands just enumerated. A total of 20 stands were selected for detailed fuel measurements, of the type concurrently being taken in the White Cap Creek drainage of the Selway-Bitterroot Wilderness; a special fuel measurement team was assigned to the Moose Creek Ranger Station area to take these fuel samples. Seventeen of the 20 stands sampled for fuel loadings were among the forest communities studied in detail by this investigator. Three other stands (including a brushfield and two open ponderosa pine-Douglas fir stands subjected to fire disturbance in 1934) were sampled by the fuel team, but were not subjected to a plot analysis by me. The lateness of the season at the time of the fuel measurements coincided with the understory species being in nearly unidentifiable condition (annuals and spring emphemerals were mostly in a dried, cured stage). The inclusion of these three stands, nevertheless, was deemed of importance in interpreting fuel characteristics among a range of community types in the Moose Creek region.

General Fire History of the Study Area

The earliest written record of fires in the Selway River/Moose Creek area is that provided by Leiberg (1900), who conducted an extensive ground reconnaissance of the entire region at the turn of the century. His report includes a detailed map illustrating the areas burned during several periods between 1719 and 1898. This fire map indicates that none of the general study areas included in this investigation exhibited evidence of past fire during the time interval given above. Recent fire maps, illustrating the acreage burned between 1880 and 1968, reveal that only portions of the 1910 fires affected segments along

the Moose Creek drainage. The affected areas occur in the region surrounding the confluence of North Moose Creek and East Moose Creek, and in the vicinity of Elbow Bend (Fig. 1). Other fires during the years 1889, 1919, 1934, and some others, did affect numerous upland acres adjacent to Moose Creek and the Selway River, but did not seriously disturb much of the lowland, cedar-grand fir forests.

A great majority of the current vegetation cover adjacent to Moose Creek is composed of intermediate to old-aged forests, ranging in age from 250 to 500 years. Young stands less than a century in age are not common. The occurrence of single and multiple fire scars on the older, larger tree individuals (particularly Douglas fir and ponderosa pine, but also including western redcedar) signifies the occurrence of past ground fires since the time of stand establishment. Such ground fires seem to have had only a transient influence on these old streamside communities. Such minor disturbance by ground fires would not have merited mapping by Leiberg.

Both ancient and more recent lightning ignitions were noted in the old-aged redcedar groves along Moose Creek. Such ignitions appear to have led only to extremely localized disturbance to either single cedar trees, or to at most 3-4 trees grouped close together; such fires displayed no spread to other portions of the groves. Complete distruction of old-aged grand-fir/redcedar stands occurred in 1910, and samples were recorded in several of the recovery stands. Considering the severity of the 1910 fire season, it is remarkable that so much of the Moose Creek cedar-grand fir forests remained intact. This study was partially hampered by the lack of stand age diversity; to successfully relate successional development and fuel accumulation, stands representative of all developmental stages ought to be well encompassed. This

aspect of the study will be addressed in greater detail in a later section of this report.

Field Methods

Vegetational Analysis: The field methodology employed in this investigation was similar to that currently employed in the USDA Forest Service project: Ecological Classification of Forest Lands in Montana, centered at the Forest Science Laboratory, Missoula, and under the direction of Dr. Robert D. Pfister. During the first half of the 1972 field season forest communities displaying a dominance of grand fir and/or western redcedar were chosen nearly at random. Later in the summer communities of younger age and older age were sought out. It was also later in the field season that less mesic habitat types were selected for study (Douglas fir&ponderosa pine) in order to supplement the fuel measurement activities.

Within each stand selected, a circular 375 m^2 plot was established (radius = 10.7 m or 35.8 ft.). Within this plot all tree individuals over 4.5 feet were tallied by 2-inch diameter (dbh) size classes. A separate tally was made of live trees and those occurring as dead, standing trees or as stumps. A separate tally was made of tree seedlings within a centralized 50 m^2 subplot (radius = 4.0 m or 13.1 ft.).

An estimate was made of the canopy coverage for each tree species in each of three diameter size classes (over 12" dbh, 4-12" dbh, and trees less than 4" dbh). Seven coverage classes were employed, viz.

Cover Class	Percent Coverage	Mid-Point
T	0-1	0.5
1	1-5	3.0
2	5-25	15.0
3	25-50	37.5
4	50-75	62.5
5	75-95	85.0
6	95-100	97.5

The understory species (vascular) were each treated in the same way employing the same coverage class scale as above; the estimates were made on the basis of their cover displayed within the 375 m^2 plot. Mosses were collectively estimated. Species observed in the stand being sampled, but not occurring within the 375 m^2 plot were recorded as "+" on the data sheets.

In addition to these plant data, stand elevation, aspect, slope (degrees), slope position (ridge, upper slope, midslope, lower slope, bench/flat, stream bottom), and slope configuration (5-175^o = convex; 176-185^o = straight; 186-355^o = concave; or undulating) were also recorded. The percentage of the stand area covered with exposed mineral soil, rock; kind of parent material; and depths of litter (L, F, and H layers) were also recorded.

In most of the stands sampled, the best-appearing, free-growing tree individual (of each species present) was selected for site productivity data measurements. Total height and diameter (dbh)and age (from an increment boring) were determined for these individuals.

As might be expected, the specific placement of the 375 m^2 plot in a given forest community was a critical decision, since a bulk of the data tabulated is from this relatively small tract. In other sampling methods (quadrat, quadrant methods) a large part of the selected community is systematically covered. In this Moose Creek study, each candidate stand

was examined prior to plot establishment. This permitted a determination of the spatial demensions of the community, and a visual assessment was made of compositional uniformity (approximately its homogeneity). The plot was then positioned in a manner that was partly objective and partly subjective.

Utilizing the knowledge gained from the preliminary examination, the plot center was determined by a method of objective pacing, but this operation was conditioned or modified by the avoidance of local topographic discontinuities and local interruptions or disruptions in the stand canopy (if not typical of the stand as a whole as was true in some of the drier community types). Since the method employed is not a random sampling technique, but a plot tallying procedure, plot placement became the resultant of an effort to have the plot located where it would be representative of the entire communitiy (as closely as possible). The total effort during the field season was to include communities of a wide range of ages and compositions (developmental stages). Since young stands of cedar and grand fir types were the least common, extra effort was expended to seek out the few that were available.

Fuel Measurement Analysis: Fuel data were collected by a specially trained team of Forest Service employees who were loaned to the Moose Creek study for a period of ten days. As was mentioned earlier a total of twenty communities was studied by this team; the array of stands sampled was selected by this investigator, however.

The techniques employed are identical to those being applied in the White Cap Creek fire studies. The fuel inventory team had approximately two months of field experience in the White Cap area prior to taking their measurements in the cedar/grand fir communities.

The field, laboratory and computer methods and procedures follow those developed by Dr. James Brown of the USDA Forest Service, Northern Forest Fire Laboratory, Missoula (Brown 1970, 1971a, 1971b, and personal communications). The details of all of the methodologies followed in the collection and analysis of the fuel data will not be repeated here. It is, however, of some importance to list the kinds of fuel information that were determined in this phase of the Moose Creek study.

The following fuel categories and characteristics were determined: (1) branchwood fuels, segmented into three diameter size classes: 0-0.5 cm, 0.5-1.6 cm, and 1.6-10.0 cm; (2) dead ground fuels greater than 10 cm; (3) fuel depth; (4) percentage of rotten wood on the forest floor; (5) amounts of live and dead grass & forbs; (6) depth of the litter layer (composed of needles, bark flakes, brush leaves and other debris); (7) depth of the duff layer (between the top of the F layer, down to mineral soil); and (8) amounts of living and dead brush. The field data were used to calculated amounts (expressed in pounds per acre) of many of these fuel categories. Further analysis of these results allows the development of predictions of fire spread in each stand.

Laboratory Analysis of Vegetation Data: The plot data collected from the 63 forest communities were subjected to two different kinds of analysis: (1) a habitat type classification, and (2) a multi-dimensional ordination. Both of these operations were done by Forest Service personnel as a result of the cooperative interaction that exists between the fire ecology project and the Montana habitat-typing project. Dr. Robert Pfister, Dr. Stephen Arno and Mr. Bernard Kovalchik performed these two analysis efforts; their help is gratefully acknowledged.

The habitat types arrived at must only be considered tentative at this time, and later discussion of the types determined should be accepted

only in this light. The habitat typing of the 63 communities was made by a close comparison with habitat types arrived at in Montana (Pfister, Arno, Presby, and Kovalchik 1972), and with work published earlier by Daubenmire and Daubenmire (1968). Differential difficulty was experienced in habitat-typing the wilderness forests because not all of the 63 stands sampled were late seral or near climax in development. The most tentative of the habitat types are several that appear to be jointly dominated by Thuja plicata and Abies grandis, but may perhaps be transient seral stages of development.

The multidimensional ordination of the 63 stands was accomplished by calculating indexes of stand similarities and dissimilarities (coefficient of similarity) following, in general, the methods first described by Bray and Curtis (1957) and Beals (1960). Presence data from the trees and understory species in each sample area was used to make the quantitative comparisons. A total of six different ordinations of the 63 stands were made; the variation among the different trials dealt with reference stand selection during the construction of the primary ("X") axis and secondary ("Y") axis. Each of the ordinations tested gave similar arrangements of the 63 stands. In all cases a majority of the compositional variation present among the 63 stands was well distributed along the primary axis. The secondary axis provided additional stand separation and delineation. There appeared no justification or usefulness in constructing a tertiary axis for this set of communities.

Results and Discussion

Preliminary Habitat Types: The following outline presents a listing of the tenetative habitat types composing the group of communities studied:

I. Thuja plicata (Western redcedar) Climax Series:[1]

The following are closely comparable to the habitat types described by Daubenmire and Daubenmire (1968) and by Pfister, etal. 1972.:

A. Thuja plicata/Clintonia uniflora h.t., Clintonia uniflora phase

Stands No. 41, 44, and 50 (see Fig. 1)

B. Thuja plicata/Clintonia uniflora h.t., Gymnocarpium dryopteris phase

Stands No. 23, 35, 42, 43, 45, 49, 51 and 57

C. Thuja plicata/Athyrium filix-femina h.t.

Stands No. 11*, 24

D. Other Thuja plicata communities:

Stands No. 47 and 48 have Xerophyllum tenax well represented in the understory of old-growth redcedar communities; this condition has been noted occasionally in western Montana, and may be more prevalent in the Nez Perce National Forest, Idaho.

II. Thuja plicata (Abies grandis) Climax Series? (Tentative):

This series contrasts with the one above in that grand fir appears to be co-dominant with, or reproducing better that western redcedar.

A. Thuja plicata (Abies grandis)/Clintonia h.t., Clintonia phase

Stands No. 8*, 13, 15*, 16, 17, 18*, 20, 22*, 36, 53, 55, 56*, 58*, 59, 61, and 62. (#58 & 61 possess Xerophyllum).

B. Thuja plicata (Abies grandis/Clintonia h.t., Gymnocarpium phase

Stands No. 5, 6*, 7*, 12*, 14, 32, 33, 39, 40.

C. Thuja plicata (Abies grandis)/ Clintonia h.t., Menziesia phase

Stands No. 19*, 21*, and 46.

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[1] Based on materials supplied by Montana Habitat-type Project, RWU-1205.

*Stands utilized for fuel measurements.

III. Abies grandis Climax Series:

This climax series appears to be more similar to the Abies grandis habitat types found in western Montana. Some of wilderness communities, however, are significantly different from those described for Montana; these are listed in the third group below:

A. Abies grandis/Clintonia uniflora h.t., Clintonia uniflora phase

Stands No. 1*, 2*, 3, 4, 9*, 10, 37, 31#, 38#.

(# = these stands display great amounts of Symphoricarpos albus, more than what is usually associated with the Clintonia union. May be seral.

B. Abies grandis/Clintonia uniflora h.t., Xerophyllum tenax phase

Stand No. 29

C. Other Abies grandis communities:

a. Stands 25 and 28: These two communities appear to be ecotonal between Abies grandis/Clintonia h.t. and Pseudotsuga menziesii/Physocarpus h.t.

b. Stands 30 and 63: These stands exhibit disturbance features (high values for Trifolium & Pteridium). These seem similar to Abies grandis/Symphoricarpos h.t. sampled in Boise N.F. and Payette N.F., Idaho.

c. Stand 54: This stand appears to be an Abies grandis/Vaccinium caespitosum community, somewhat similar to the Pseudotsuga menziesii/Vaccinium caespitosum h.t. described for western Montana.

IV. Pseudotsuga menziesii Climax Series:

The drier forest communities included were the most difficult to deal with; they were not sampled until August, and a total species listing could not be made. Disturbance by prior fire and currently by wildlife may be responsible for the occurrence of exotic invader species.

A. Pseudotsuga menziesii/Calamagrostis h.t., Agropyron spicatum phase

Stand No. 52*: This is an approximate classification of a seral community. High cover values for Pteridium like that found here, has not been noted in any Pinus ponderosa h.ts. in Montana, but has been reported in the Nez Perce N.F. west of the wilderness.

B. Pseudotsuga menziesii/Calamagrostis rubescens h.t.

Stand No. 60 This is the best approximation for a seral stand.

C. Pseudotsuga menziesii/Symphoricarpos h.t., Agropyron spicatum phase:

Stand No. 34: Located above Selway River Lodge; recent fire and grazing history. Habitat type only approximate.

D. Pseudotsuga menziesii/Physocarpus malvaceus h.t.

Stands No. 26 and 27: Both stands are portions of winter elk range on south slopes above Selway River. Invader species present and complicate classification.

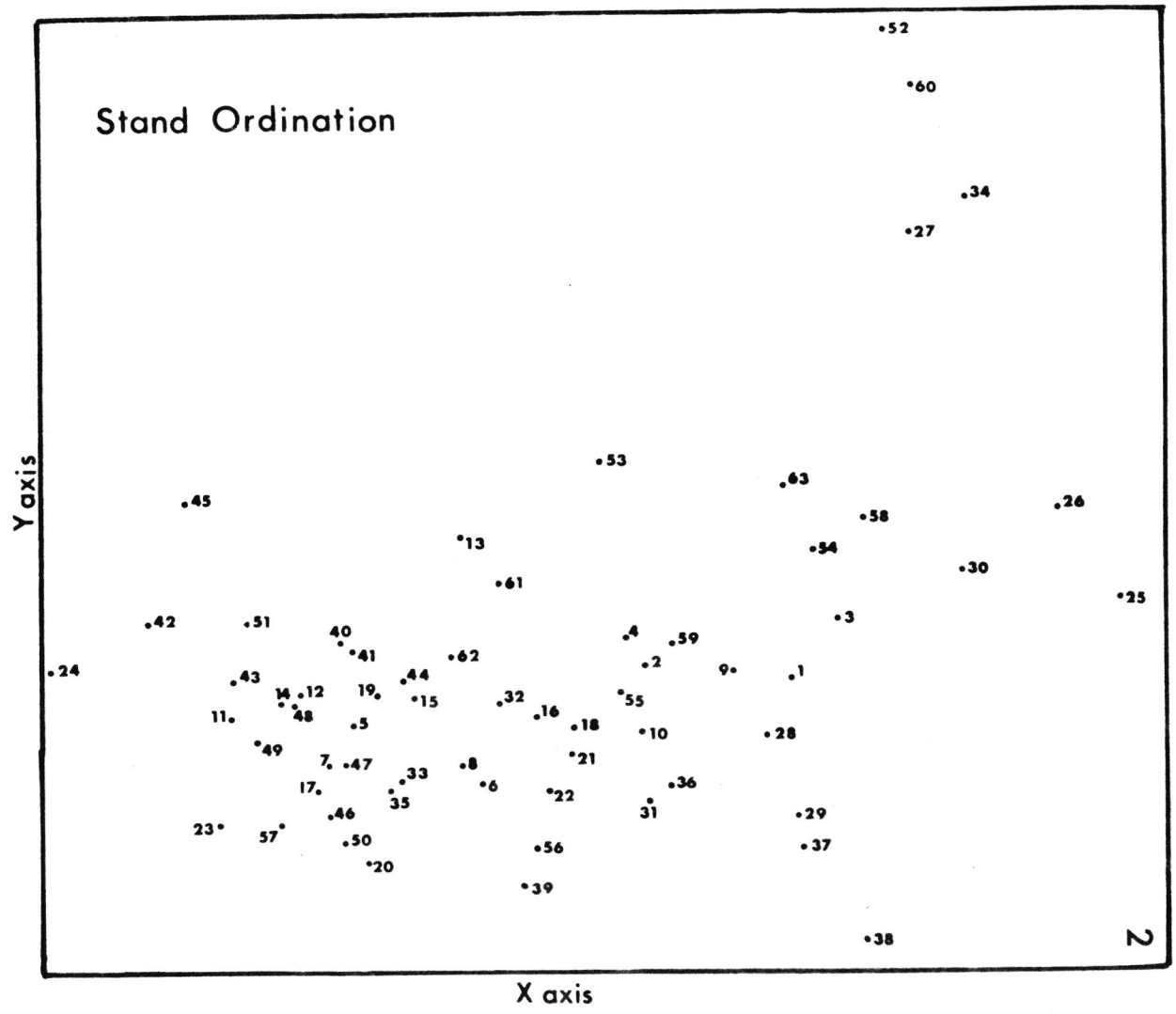
The fact that fifteen of the 63 communities sampled were classified in the Thuja plicata climax series, and another 28 stands were tentatively classified in a Thuja plicata (Abies grandis) series, is a clear indication of the emphasis that centered about the streamside community types in this study. The determination of 3 h.ts. & phases in each of these climax series

reveals that a range of variation among potential climax types does exist. Climax habitat types that suggest single dominance by Abies grandis (another additional 15 stands) are also varied. Some of these 15, due to either recent disturbance or due to their stage of development, did not submit to clearcut classification by the methods and techniques available. It is hoped that members of the Montana habitat typing project can make direct examinations of these communities, during an early season period, so that further clarification can be made.

More will be said about these habitats shortly. An evaluation of the usefulness of these types in the present study is necessary, of course, and such will be made after some preliminary information is provided about the results of the multi-dimensional ordination.

Community Ordination Results: Figure 2 presents the stand ordination that will be the basis for further stand and data interpretation. Each community in this ordination is represented by a point and a stand number. The stand numbers are the same as listed in the habitat type outline. It can be noted in Fig. 2 that clustering occurs among the stands located in the lower, lefthand section of the ordination, with only a small amount of vertical sepration along the Y axis. A greater amount of such separation was achieved among the communities located on the righthand portion of the ordination.

The first type of information that was inserted into this ordination relates to geographical locations of the 63 stands. Through a series of seven different symbols (noted in Fig. 3), the locations of the stands are plotted. The solid, black dots, used for stands in the vicinity of the Moose Creek Ranger Station, appear to have the widest distribution within


Stand Ordination
Y axis
X axis
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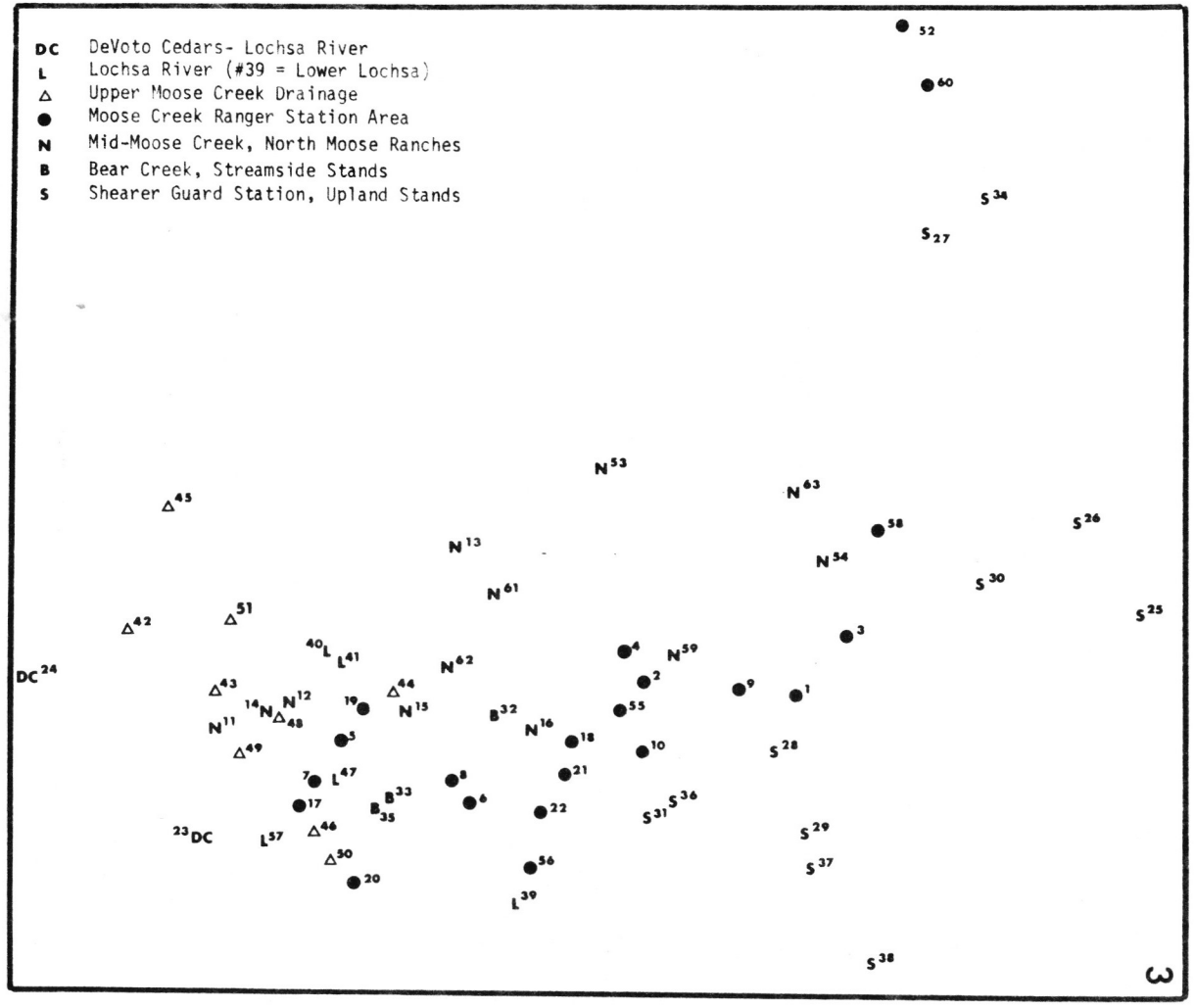
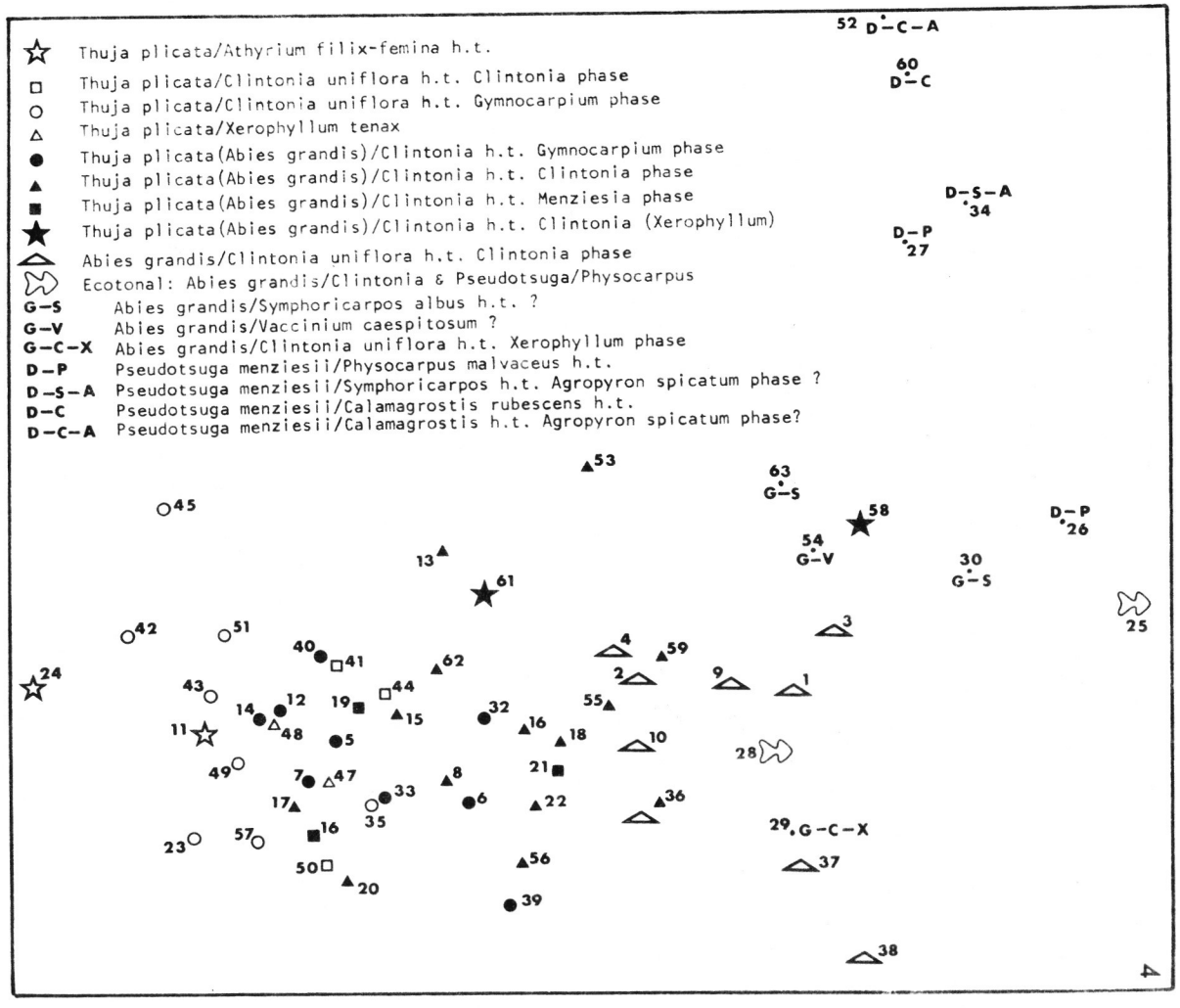

DC DeVoto Cedars- Lochsa River
L Lochsa River (#39 = Lower Lochsa)
△ Upper Moose Creek Drainage
● Moose Creek Ranger Station Area
N Mid-Moose Creek, North Moose Ranches
B Bear Creek, Streamside Stands
S Shearer Guard Station, Upland Stands
52
60
S34
S27
N53
N63
58
S26
△45
N13
N54
S30
N61
△42
△51
S25
3
40L
L41
4
N59
DC24
N62
2
△43
△44
9
1
14N
N12
19
N15
B32
55
N11
△48
N16
18
S28
△49
5
10
7
L47
8
21
B33
17
6
S31
S36
B35
22
23DC
L57
△46
S29
△30
56
S37
20
L39
S38
3

the ordination. This does reflect the attempt to include the widest range of forest community types in the area; this effort was augmented late in the season when further effort was made to include drier types (Douglas fir/Ponderosa pine mixtures) as a part of the fuel measurement phase of the project. Thus stands ranging from wet cedar to dry upland stands in the MCRS area are included.

The same range of community types was not achieved in any other single geographical location; time limited the degree of stand sampling. The stands in the Shearer Guard Station/Bear Creek area (="S" and "B" in Fig. 3) located up the Selway River, come close to encompassing a range of communities from streamside and upland sites. It should be noted that many of the Shearer sites are clustered within the lower, righthand side of the ordination, and not scattered about at random.

Most of the upper Moose Creek and upper Lochsa River stands (="DC", "L", and triangles in Fig. 3) are also clustered within the ordination, on the lefthand side of the stand array. And these are joined by other stands located along the Moose Creek and Bear Creek drainages. It may be recalled that the specific position achieved by any single stand is based on the stand's composition, and communities that are similar to numbers and kinds of plant components will occur close to one another in this ordination. Some further, small amount of stand separation is likely to have occurred if a third (tertiary) axis had been constructed, but examination of the data reveals that much of the variability among these stands is accounted for in this two-dimensional ordination.

With this ordination at our disposal, further discussion of the habitat classification can be made. Within Fig. 4, a system of symbols has been employed to plot the habitat types in this ordination. When this


Thuja plicata/Athyrium filix-femina h.t.
Thuja plicata/Clintonia uniflora h.t. Clintonia phase
Thuja plicata/Clintonia uniflora h.t. Gymnocarpium phase
Thuja plicata/Xerophyllum tenax
Thuja plicata(Abies grandis)/Clintonia h.t. Gymnocarpium phase
Thuja plicata(Abies grandis)/Clintonia h.t. Clintonia phase
Thuja plicata(Abies grandis)/Clintonia h.t. Menziesia phase
Thuja plicata(Abies grandis)/Clintonia h.t. Clintonia (Xerophyllum)
Abies grandis/Clintonia uniflora h.t. Clintonia phase
Ecotonal: Abies grandis/Clintonia & Pseudotsuga/Physocarpus
G-S Abies grandis/Symphoricarpos albus h.t. ?
G-V Abies grandis/Vaccinium caespitosum ?
G-C-X Abies grandis/Clintonia uniflora h.t. Xerophyllum phase
D-P Pseudotsuga menziesii/Physocarpus malvaceus h.t.
D-S-A Pseudotsuga menziesii/Symphoricarpos h.t. Agropyron spicatum phase ?
D-C Pseudotsuga menziesii/Calamagrostis rubescens h.t.
D-C-A Pseudotsuga menziesii/Calamagrostis h.t. Agropyron spicatum phase?
52 D-C-A
60 D-C
D-S-A 34
D-P 27
63 G-S
58
D-P 26
54 G-V
30 G-S
25
53
45
13
61
42
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62
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48
5
10
28
49
7
47
8
21
17
33
6
22
36
35
29 G-C-X
23
57
16
56
37
50
20
39
38
4

arrangement is examined, relationships can readily be found between the habitat types and the stand placements within the ordination. The moist Thuja plicata climax types are concentrated on the righthand side of the ordination (Open stars, open squares, circles and small triangles). In the mid-section of the ordination there is a concentration of habitat types in the Thuja plicata (Abies grandis)climax series (black stars, black circles, small triangles and squares).

Just to the right of the mid-section are communities representative of the Abies grandis climax series (Large open triangle, "G-S", "G-V", "G-C-X", and open arrow). The remaining stands on the righthand side of the ordination (actually upper righthand corner) are potentially (and tentatively) members of the Pseudotsuga menziesii climax series.

Further reflections upon Fig. 4 do not reveal that these four climax habitat type series are discontinuous. A system of lines may be constructed through these stands that partially separate many of those belonging to one series, from those of another, adjacent series. But such an operation would fail to discriminate discrete series units. The effort would be completely fruitless if attempted on the individual habitat types and phases themselves.

The ordination is based on stand compositions existing during the summer of 1972. Many of the cedar and grand fir communities included in this study are indeed intermediate to old age, approaching ecosystem maturity. The habitat typing process involves an interpretation of the potential, ultimate stage of development (= climax); clues are taken, of course, from what the current compositions are, but this information is used in making projections and predictions of the potential climax type.

The recognition of a climax series codominated by both Thuja plicata and Abies grandis in the Moose Creek study areas is given support by the fact that the stand samples that seem to fit such a category are not entirely young, pioneer stands whose interspecific competitive relationships remain to be sorted out. The majority of the stands placed in this codominated climax series are not particularly young; it has been pointed several times that young stands were difficult to find.

The 63 stand ordination appears to represent a moisture gradient from wet-mesic streamside sites, to meso-xeric (perhaps xeric) upland slopes adjacent to the valleys. The elevational displacement is really not great considering the elevational differences that exist in the study area. The elevations range from about 2200 feet to about 3500 feet (excluding one sample from 4500 feet). The higher elevations are of importance, however, since these are achieved at up-stream sites (upper Moose Creek, upper Lochsa River), and not simply on upslope positions above the streambeds.

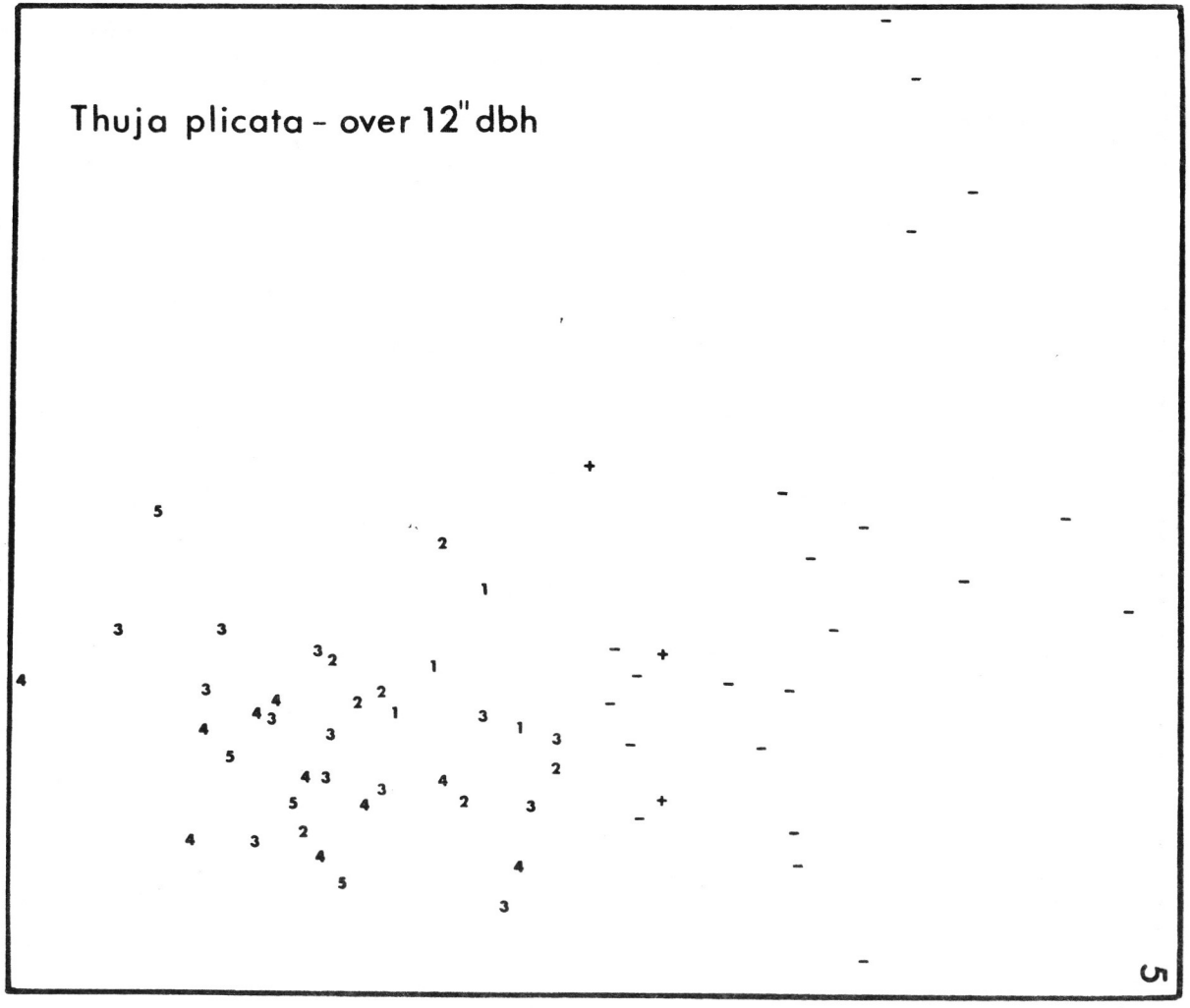
The importance of position, either on the upper or lower segments of the Lochsa River or Moose Creek, is illustrated simply by the Lochsa River stand group: stands 39 and 40 are at lower and mid positions respectively, and are classed as members of the Thuja-Abies climax series, while the upper Lochsa stands are all members of the more mesic Thuja climax series. The upper, mid and lower sampling sites along Moose Creek show a similar arrangement.

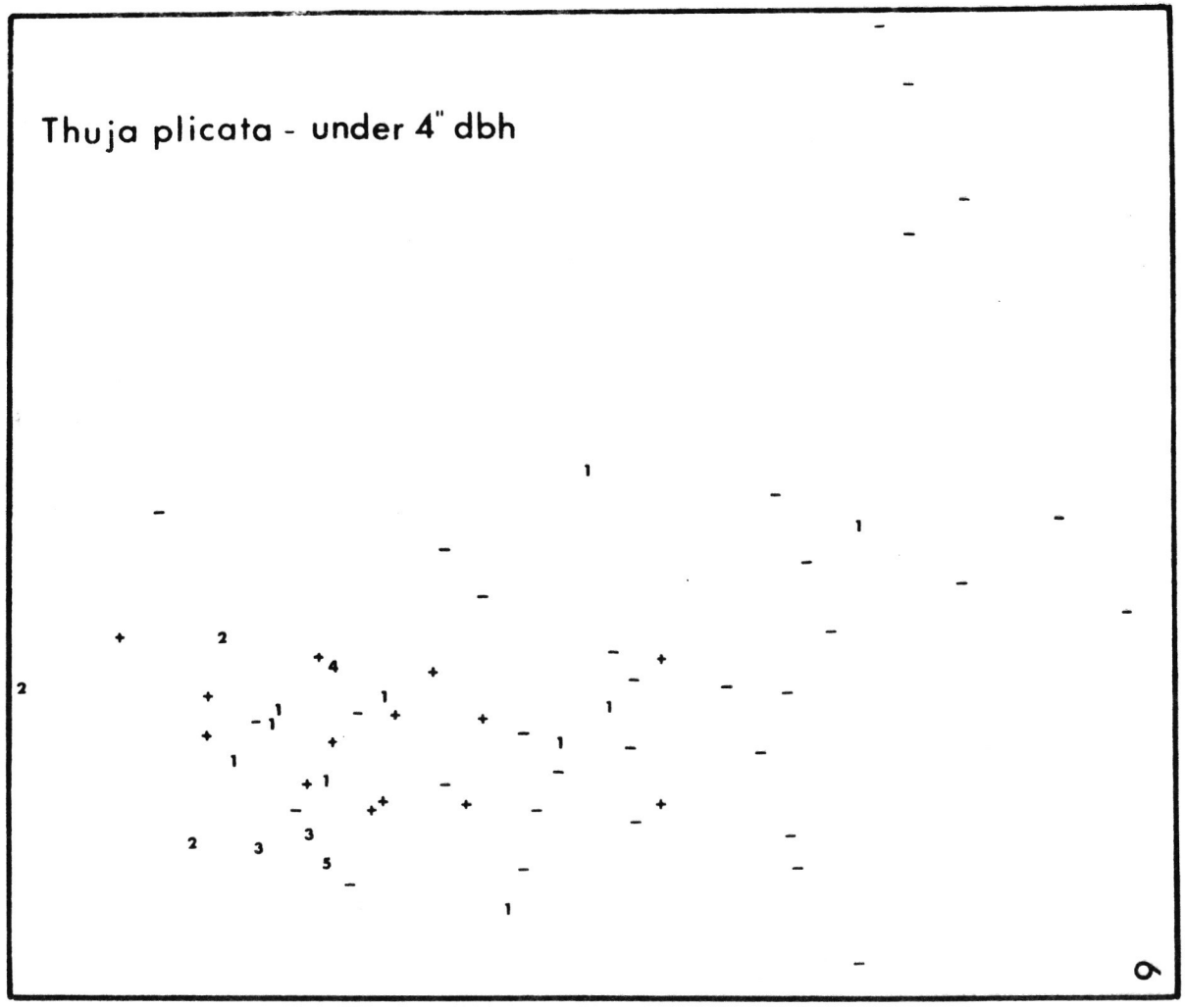
The drier Abies climax community types, and those of the Pseudotsuga series do occur on less mesic sites; the former on better drained benches located above stream level, and the latter on upland slopes that are well drained. The arrangement of habitat types within the ordination

however suggests that the 63 communities included in this study form a vegetational continuum, whose plant components arrange themselves in rather smooth patterns along this moisture/elevational gradient. It appears that the only sharp discontinuities in the ordination are the resultant of the inclusion of a low number of upland stands. Some of the better-drained bench sites display populations of both Abies grandis and Pseudotsuga menziesii that may represent intermediate climax types (stands 25 and 28, and others) of a series that might be better labeled Abies-Pseudotsuga. Such stands were not as intensely sampled as the more mesic types, but the discontinuities present in the ordination might be removed by additional sampling of the better drained sites.

As a direct extension of the above thoughts, it appeared that further analysis of these plot data would be benefitted by using "gradient analysis" techniques. Consequently the coverage class data for each species in each stand was plotted on the ordination. The cover classes plotted are the same as those listed on page 10, however the lowest values (T's and +'s) were united into a single designation, "+". The distribution of these cover values for Thuja plicata, Abies grandis, and Pseudotsuga menziesii for individuals over 12" dbh and individuals under 4" dbh, are illustrated in Figs. 5-10; Pinus ponderosa coverage for individuals over 12" dbh only is given in Fig. 11. The dash lines in each figure represent stand locations that do not contain the designated species.

Figure 5 reveals the pattern of redcedar distribution and cover values attained by mature or nearly mature cedars. On the extreme lefthand side of the ordination redcedar exhibits coverages consistently

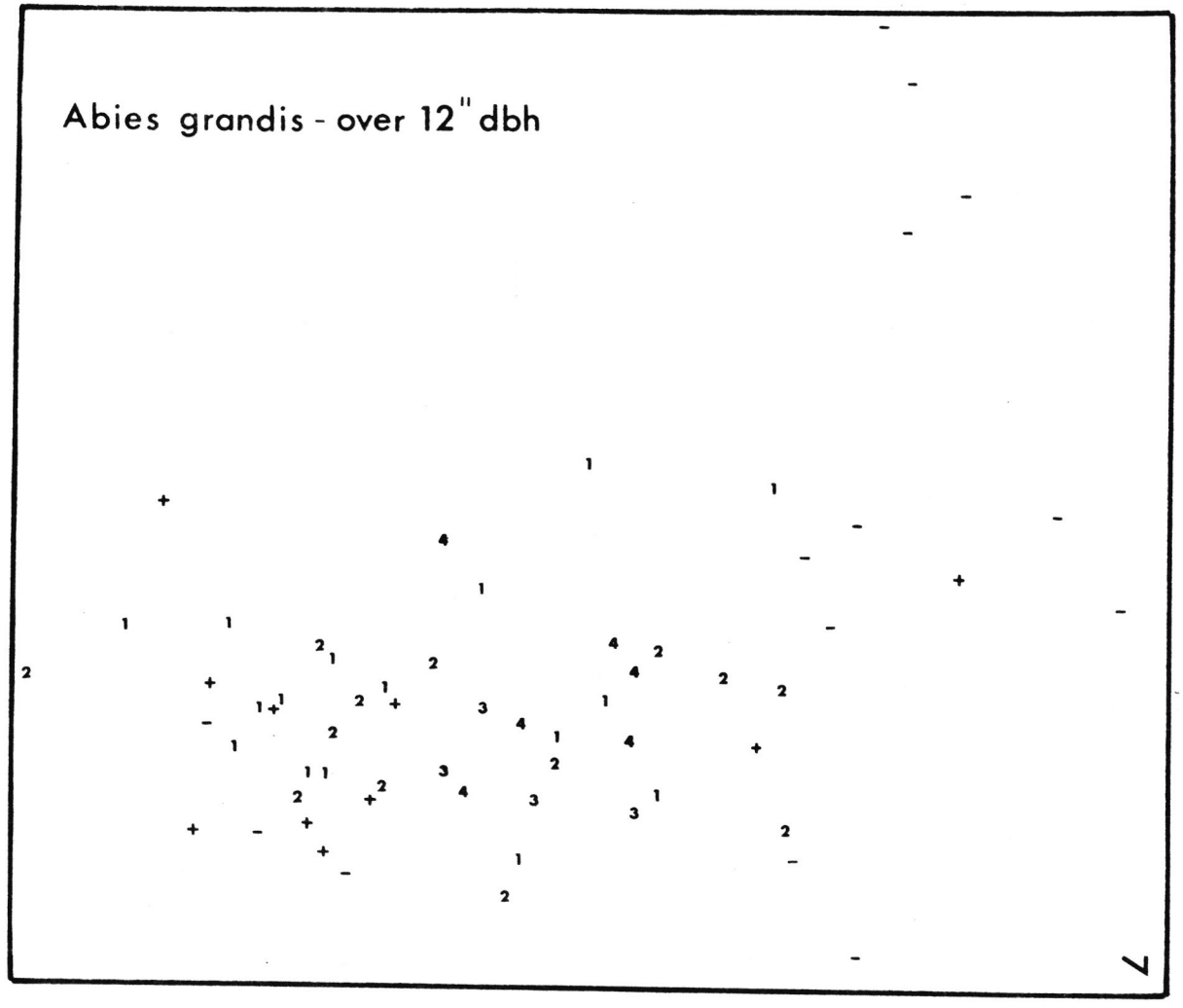

Thuja plicata - over 12" dbh
5

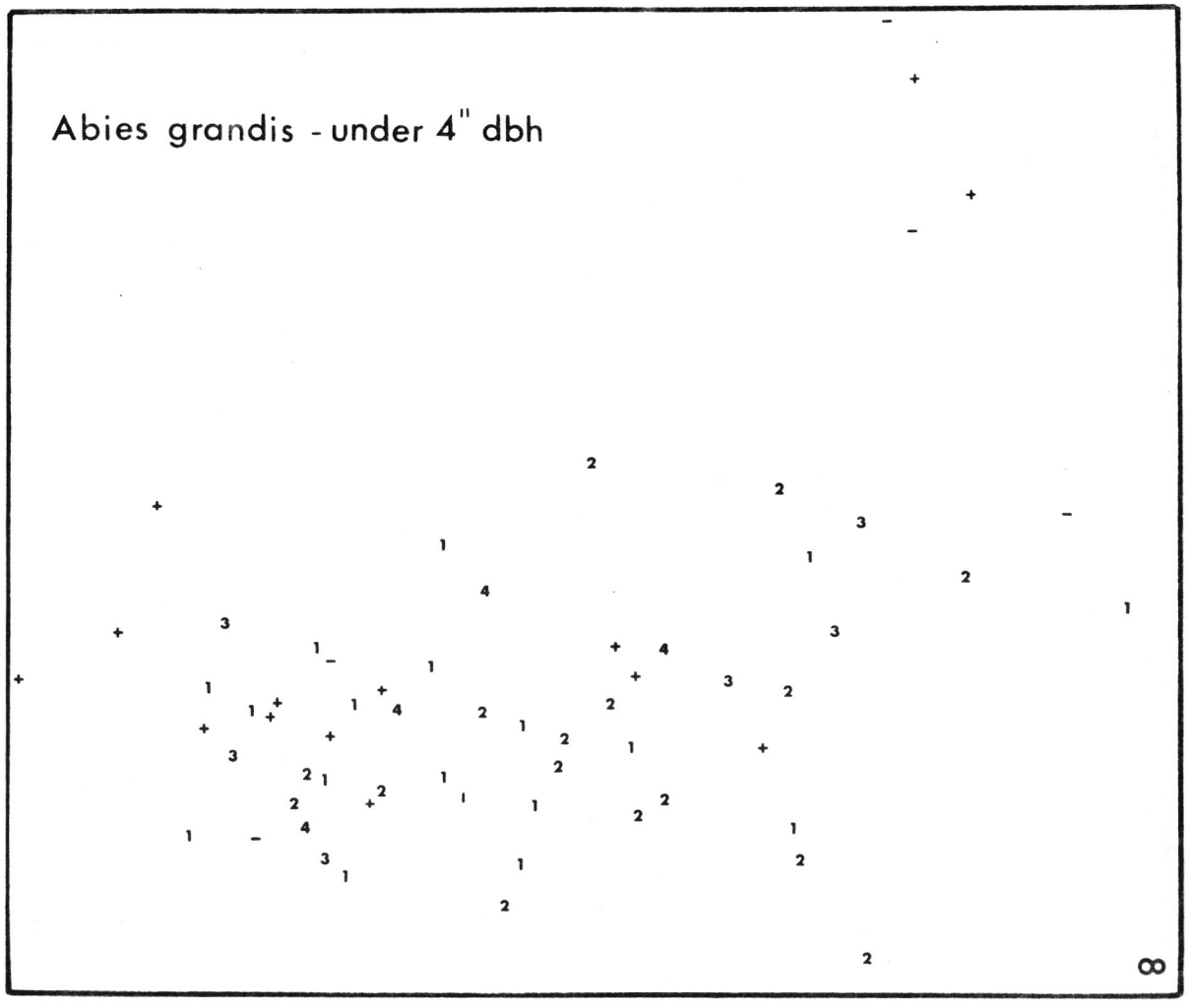

Thuja plicata - under 4" dbh
26
6

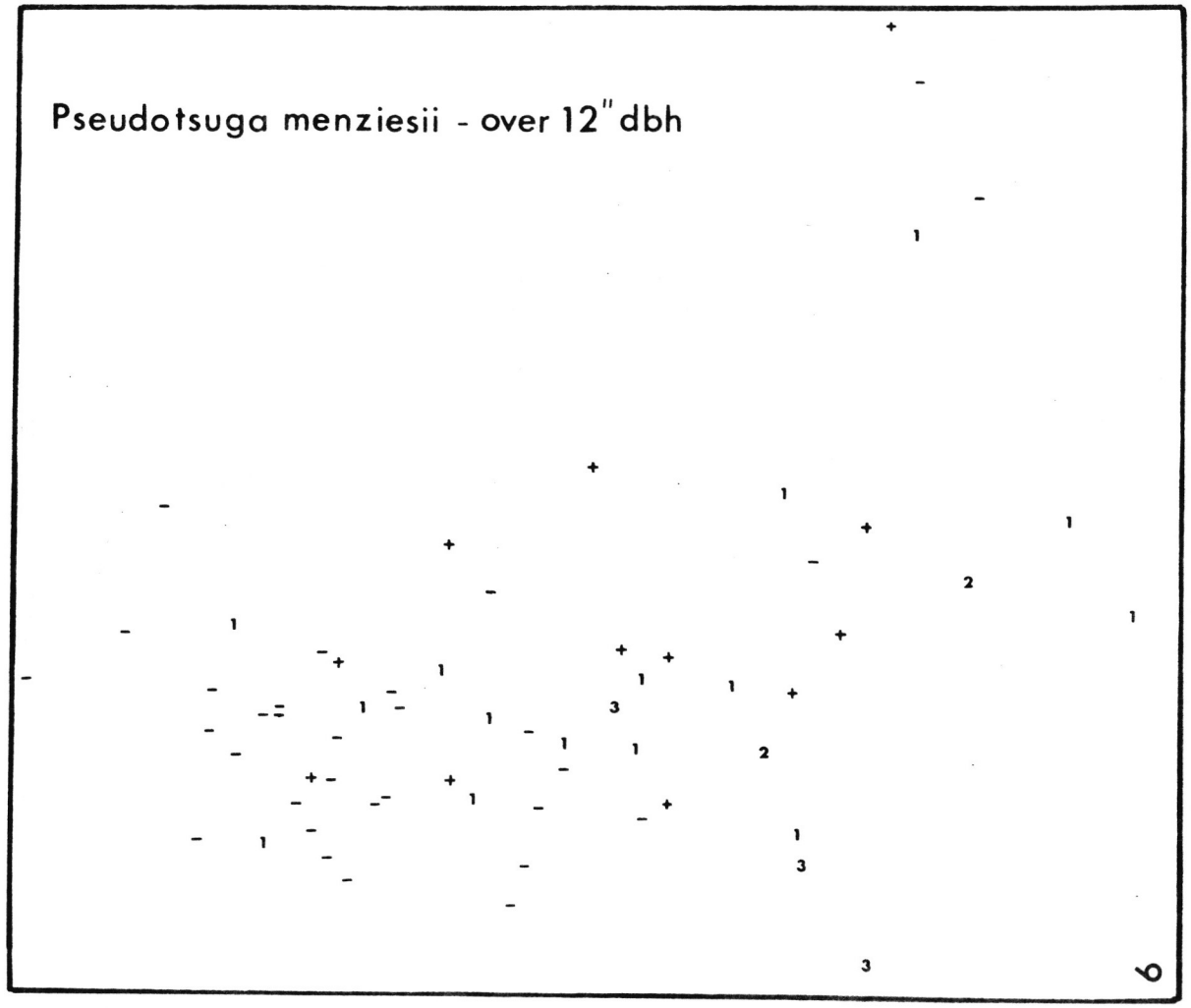
over "3" (37.5%) and often either "4" or "5" (approx. 60-90%). At the midsection of the ordination, larger diameter redcedar compose less cover or are completely absent (1-40%). Cedars over 12" dbh do not occur in the remaining righthand stands. A rather pronounced difference exists in the coverage data for redcedar less than 4" dbh (Fig. 6). Only within four of the stands does redcedar sapling data achieve values of "3" or higher; in many of the stands where cedar has high coverage for trees over 12" dbh, trees less than 4" dbh are between 0-15%. In comparing sapling coverage values and stand locations (Fig. 3) it is noted that Thuja plicata exhibits values of "2" (15%) or higher, (for under 4" dbh) only in the upper Lochsa River and Upper Moose Creek drainages. Where smaller dimensioned cedars do occur, they have coverage values of 3.0% or less.

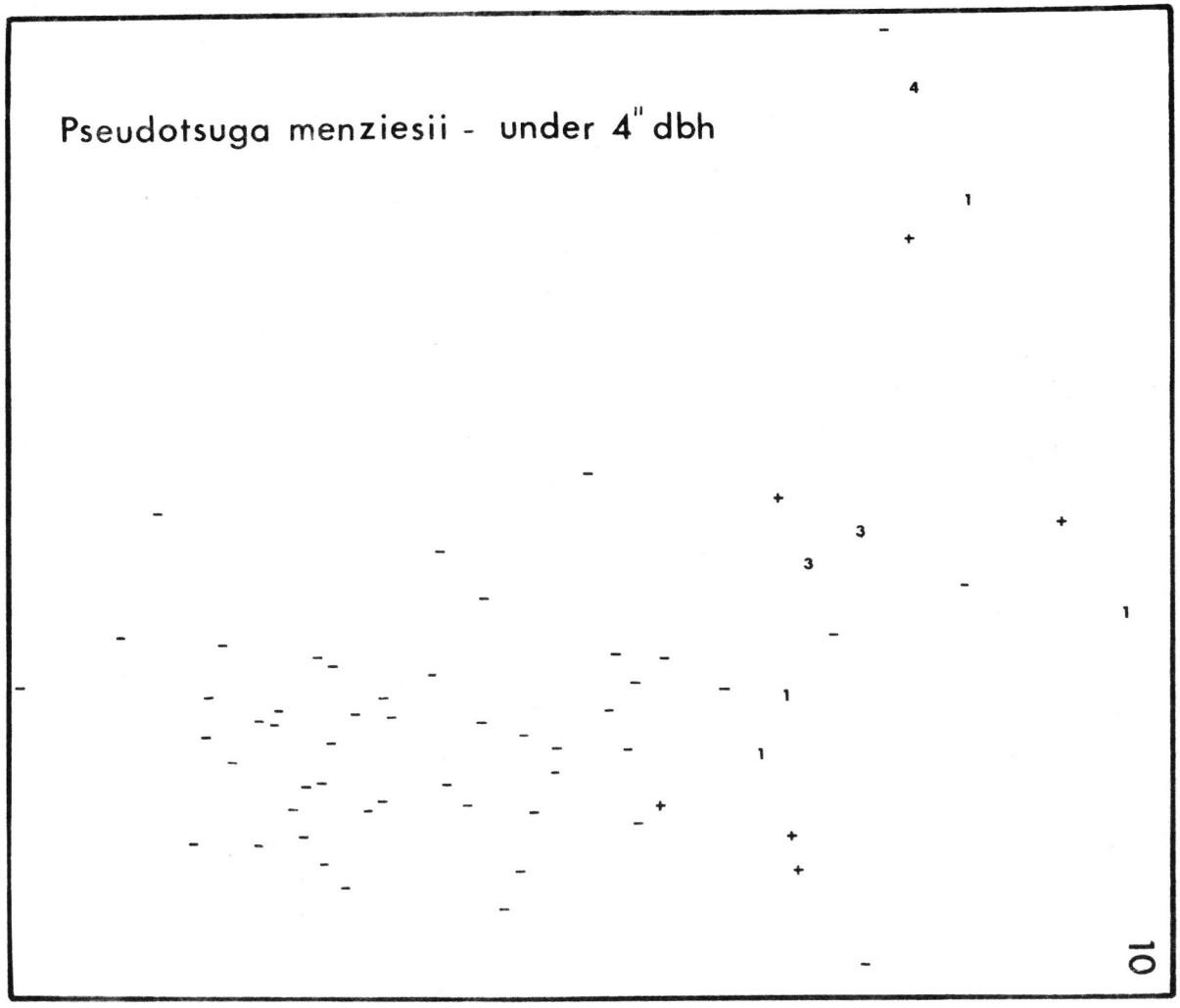
In the case of Abies grandis (Figs 7 & 8), the highest coverage values of trees over 12" dbh are among the stands centrally located in the ordination, but values of "1" and "2" are widely distributed in all but the upper righthand stands. Grand fir less than 4" dbh is extremely wide spread among the 63 stands ordinated. Only five stands lacked grand fir reproduction of some amount. Coverage of grand fir reproduction reaches values between 15 and 40% in both the moist stands and the drier stands.

The data for Pseudotsuga menziesii (Figs. 9 & 10) reveal its reduced abundance among the stands sampled. It displays its highest values among the righthand stands in the oridnation which earlier were described as less mesic. The low coverage values for Douglas fir among the cedar-grand fir dominated stands relates to its persistence as old-aged seral members in such stands. The low values for larger


Abies grandis - over 12" dbh
28
7

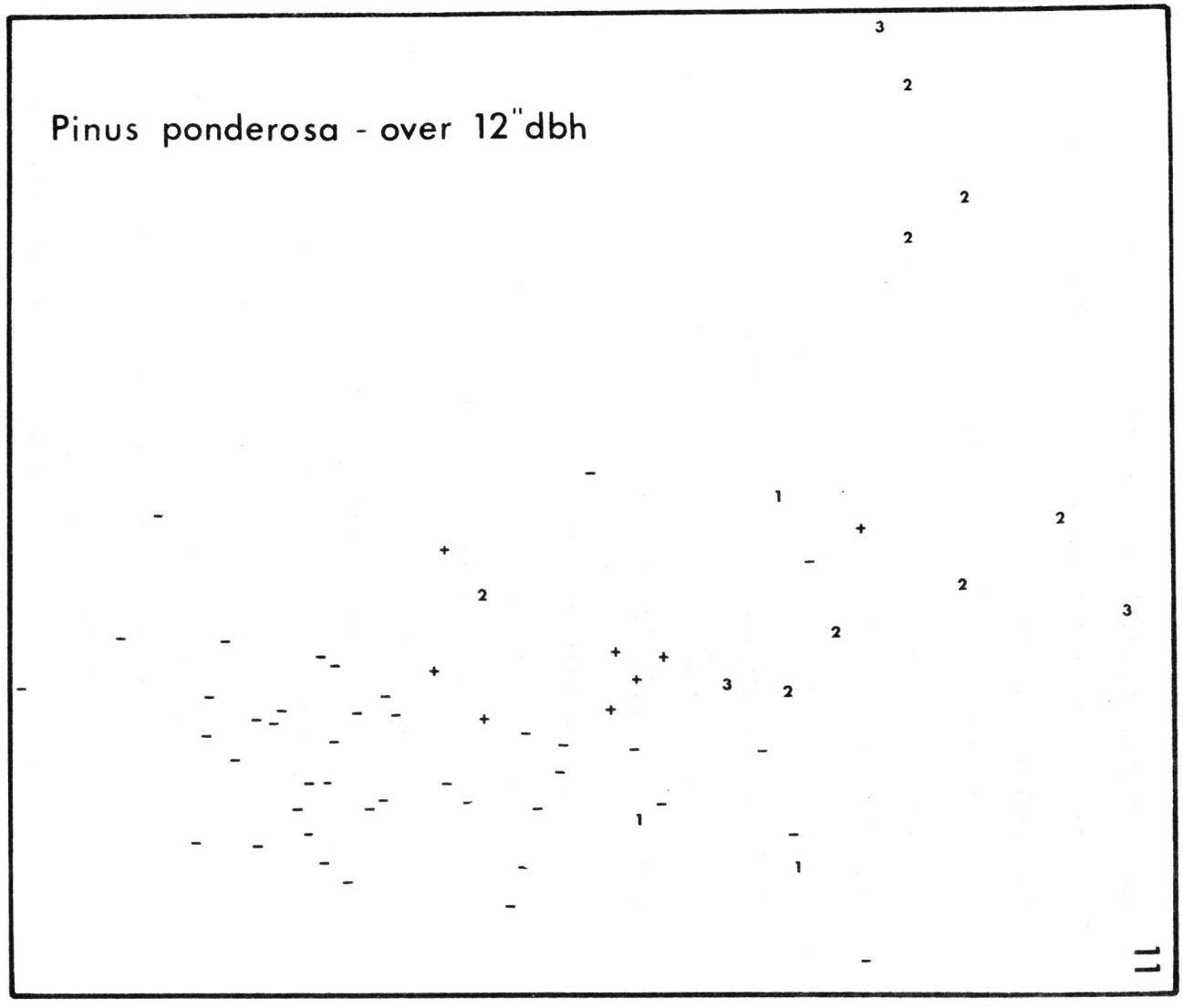

Abies grandis - under 4" dbh
8


Pseudotsuga menziesii - over 12" dbh
30
9


Pseudotsuga menziesii - under 4" dbh
10

Douglas firs among the drier stands (righthand stands in ordination) reflect the seral status of some of these communities. It remains a possibility that some instances occur where Douglas fir and grand fir will be codominants in the mature stages of community development. It is also expected that with continued fire suppression on upland sites, that greater coverage values will be attained by Douglas fir. Since the upland terrain was not subjected to exhaustive analysis, it is possible that such stands currently exist. Douglas fir in the Selway-Bitterroot Wilderness no doubt can and does play the roles of a minor seral, major seral, minor climax and major climax species.

Ponderosa pine (Fig. 11) achieved relatively high coverage values in most of the drier, upland communities (righthand communities in ordination), but is also present in small to moderate amounts in the more mesic grand fir communities (central portion of ordination). Based on the habitat typing analysis of these stands, none are classed as members of the Pinus ponderosa climax series, and thus ponderosa pine's function among these communities may be that of a seral species (minor among the grand fir communities; major among the Douglas fir communities.). It still remains a possibility that some of the drier communities, on steep slopes, could potentially achieve a climax state wherein both Douglas fir and ponderosa pine can perpetuate themselves. The status of the Douglas fir/ponderosa pine stands should remain tentative until further data are collected. It is significant perhaps that ponderosa pines less than 4" dbh were recorded in stands 27, 34, 52 and 60 (only) and these four stands are grouped in the upper, righthand corner of the ordination.


Pinus ponderosa - over 12"dbh
11

The coverage values for these tree species is such that it seems likely that what exists is a continuously changing pattern of climax community types arranged along complex environmental gradients. If climax types need to be delineated, it is possible to utilize the habitat types that have been described earlier, although these are not clearly discontinuous from one another. Larger units, such as the climax series, might also be recognized; these seem to delineate themselves within the ordination with greater clarity. It is likely that the following climax series may be present: (1) Thuja plicata, (2) Thuja plicata-Abies grandis, (3) Abies grandis, (4) Abies grandis-Pseudotsuga menziesii*, (5) Pseudotsuga menziesii, (6) Pseudotsuga menziesii-Pinus ponderosa* and perhaps (7) Pinus ponderosa*.

A somewhat different approach to analyzing the tree data in the 63 stand sample, but still representative of a gradient analysis technique, involves the summarizing of species coverage values along the primary axis of the ordination. The arrangement of the stands along the primary axis is the starting point; the ordinational axis was divided into six equal segments of 15 axis units each. The stands within each segment were then examined and the coverage values (not cover class numbers) were averaged. The mid-point values given on page 10 were the values used in this operation. Table 1 presents the results of these calculations.

Each of the five tree species analyzed, in each of three diameter size classes, displays a somewhat different arrangement along the compositional gradient (primary ordinational gradient). Thuja plicata clearly exceeds Abies grandis in coverage of trees over 12" dbh in

* Not recognized in tentative habitat typing analysis.

Table 1. Average percent coverage values for tree species, in each of three diameter size classes, within each of six (6) compositional gradient segments (primary ordinational axis).

Species	Compositional Gradient Segments					
	1	2	3	4	5	6
A:Over 12" dbh						
Thuja plicata	47.5	40.5	32.3	0.2	0.2	0
Abies grandis	3.1	5.1	27.5	24.9	4.3	0.1
Picea engelmannii	0.1	2.4	1.4	0.3	0	0
Pseudotsuga menziesii	0	0.3	1.0	6.3	7.8	5.2
Pinus ponderosa	0	0	1.2	4.1	9.4	24.4
B: 4-12" dbh						
Thuja plicata	6.1	11.7	6.2	4.3	0.1	0
Abies grandis	2.7	19.7	17.4	16.6	12.1	4.5
Picea engelmannii	0	0.6	0.3	0.1	0	0
Pseudotsuga menziesii	0	0	0.1	6.1	6.0	10.8
Pinus ponderosa	0	0	0	0.3	0.6	0
C: less than 4" dbh						
Thuja plicata	5.1	12.6	1.7	0.9	0.1	0
Abies grandis	1.2	13.9	13.7	13.9	15.1	4.6
Picea engelmannii	0.1	1.8	0.5	0.1	0	0
Pseudotsuga menziesii	0	0	0	4.1	9.4	1.5
Pinus ponderosa	0	0	0	0	0.3	0.7

gradient segments 1 and 2; these two species have nearly equal average cover in segment 3; and redcedar is nearly absent in the larger size classes in the remaining segments. Both Pseudotsuga menziesii and Pinus ponderosa display an opposite response along this gradient.

Among the 4-12" dbh trees, Abies grandis exceeds Thuja plicata coverage in all but the first segment. This is also true in the case of the smaller-diameter trees in the "under 4" dbh" size class. Segment 1 of the gradient is a summary of stands that are members of the Thuja plicata climax series. In these stands the dominance of redcedar is striking, and grand fir appears to play the role of a minor climax species only. Segments 2 and 3 include stands that mostly fall into the Thuja (Abies) climax series that has been tentatively described. In these gradient segments both redcedar and grand fir are well represented in all diameter size classes.

In gradient segment 4, stands that are representative of the Abies grandis climax series are summarized. Thuja is still present among these stands, but cover values are very low (reverse of situation in segment 1). Both segments 5 and 6 include some stands that were classified as members of the Pseudotsuga climax series. As can be detected in the ordination itself, the Y axis does separate the grand fir and Douglas fir stands to a degree. Temperature factors related to slope position might be involved here. Segment averages in this part of the ordination require greater care in interpretation. Climax series that might involve the joint occurrence of Abies grandis and Pseudotsuga may exist, but more field data are needed to demonstrate this.

Employing the same compositional gradient, a series of other community-structural features were summarized (Table 2, parts A-L). Total basal area, basal area/species, individuals per species, and

Table 2. Summary of structural features for wilderness communities. The data on numbers and sizes of trees have been averaged for stands within each of six compositional gradient segments. Data are provided only for the five most common conifers; stand averages do include data from less common species such as Betula papyrifera, Larix occidentalis, Pinus contorta and P. monticola. Data for dead trees and stumps are given for Thuja plicata and Abies grandis only.

Characteristics	Compositional Gradient Segments					
	1	2	3	4	5	6
A. Average Total Basal Area (Sq. inches)/ 375 m^2 Plot: All Species:						
	11,390	5,915	4,572	2,846	1,914	1,824
B. Average Basal Area (Sq. inches)/ Species/ 375 m^2 Plot:						
Thuja plicata	10,742	4,462	2,260	64	41	0
Abies grandis	648	935	1,910	1,638	380	93
Picea engelmannii	0.2	30	104	19	0	0
Pseudotsuga menziesii	0	82	232	761	448	483
Pinus ponderosa	0	0	66	321	943	1,249
C. Average Number of Individuals/Species/ 375 m^2 Plot: All Sizes, 0-30+" dbh:						
Thuja plicata	10.3	14.9	8.5	2.6	0.9	0
Abies grandis	1.7	19.3	17.5	22.5	14.6	3.0
Picea engelmannii	0.2	3.5	1.8	0.3	0	0
Pseudotsuga menziesii	0	0.3	0.6	7.3	9.2	10.2
Pinus ponderosa	0	0	0.7	1.2	3.7	8.2

Table 2 (continued)

Characteristics	Compositional Gradient Segments 1	2	3	4	5	6
D. Average Number of Species Individuals/ 375 m^2 Plot: All Species 0-30+" dbh:						
All Species:	12.7	35.9	29.1	35.5	31.3	21.5
E. Average Number of Individuals/Species/ 375 m^2 Plot: Only Trees 2" dbh or Larger:						
Thuja plicata	8.5	11.7	8.4	2.2	0.9	0
Abies grandis	1.3	14.1	13.4	17.7	8.2	2.2
Picea engelmannii	0	2.3	1.6	0	0	0
Pseudotsuga menziesii	0	0.3	0.6	6.7	7.0	6.0
Pinus ponderosa	0	0	0.7	1.2	3.1	5.5
F. Average Number of Individuals/Species/ 375 m^2 Plot: Trees Over 2" dbh Only:						
All Species:	10.0	28.1	23.4	29.5	22.0	13.5
G. Average Basal Area (Sq. inches)/Species Individual/Plot: Only Trees Over 2" dbh:						
Thuja plicata	1264	382	269	29	(452)*	0
Abies grandis	486	66	142	92	46	41
Picea engelmannii	0	131	65	0	0	0
Pseudotsuga menziesii	0	313	377	113	64	80
Pinus ponderosa	0	0	855	267	253	151

* Value in segment 5 for redcedar caused by single, large, surviving tree in stand 59 which was affected by 1910 fire.

Table 2 (continued)

Characteristics	Compositional Gradient Segments					
	1	2	3	4	5	6
H. Average Number of Dead, Standing Trees/375 m^2 Plot:						
Thuja plicata	0.6	1.4	0.8	0.1	0	0
Abies grandis	0.5	2.3	3.6	2.4	1.1	0.2
I. Average Basal Area of Dead, Standing Trees: (Square Inches):						
Thuja plicata	76	24	58	1	0	0
Abies grandis	269	67	96	38	6	1
J. Average Number of Dead Stumps/ 375 m^2 Plot:						
Thuja plicata	0.2	0.4	0.2	0	0	0
Abies grandis	0	0.6	0.6	0.3	0	0
K. Average Basal Area of Stumps (Square Inches):						
Thuja plicata	804	294	20	0	0	0
Abies grandis	0	240	102	19	0	0
L. Average Number of Saplings (less than 4.5 ft)/ Species/ 50m^2 Subplot:						
Thuja plicata	3.1	11.5	2.1	0.7	0.2	0
Abies grandis	1.0	8.7	9.4	3.9	4.9	3.0
Picea engelmannii	0	1.2	0.7	0	0	0
Pseudotsuga menziesii	0	0.2	0.3	0.4	2.1	6.0
Pinus ponderosa	0	0	0	0	4.2	6.8

numbers and sizes of standing dead trees and stumps are averaged within each of the gradient segments. For living trees, only data for the five most common conifers are presented; for dead snags and stumps, only the data for redcedar and grand fir are presented.

Much of the data in Table 2 supports the coverage data presented in Table 1. The moist redcedar grove communities (segment 1) have very high average basal areas, far exceeding what is seen in any other community type in the Selway-Bitterroot Wilderness. The average total basal area is nearly ten times that supported by the drier communities (segment 6). The arrangement of the basal area among the five species (Table 2-B) clearly delineates the importance of redcedar. Cedars with diameters between 50-70" dbh are not uncommon in the old-growth groves; grand fir simply does not possess the size potential of cedar. The largest grand fir witnessed during the entire study exhibited a diameter of 48" dbh; diameters over 40" dbh are generally uncommon.

Numbers of trees per plot (Table 2-C, 2-D) is a variable feature, but the lowest densities occur in the old-aged cedar stands. The average number of trees between 0-30+" dbh is nearly the same in segments 2-5 (ranging from 29 to 36 trees/plot); segment 6 stands average about 21 trees. When the smallest size class is not counted (those in the 0-1" dbh class), there are significant drops in all gradient segments (but least in segment 1).

Table 2-G reveals how the average basal area of individuals over 2" dbh differs among the six segments. The data simply reveal the increased average size attained with age. Only one stand in segment 5 (out of eleven stands averaged) contains Thuja plicata (24" dbh), and this single survivor of the 1910 fire accounts for the irregularity in

cedar data. This stand (#59) is classed as a potential member of the Thuja (Abies) climax series, but occurs within the ordination nearly among the Abies climax communities. Within this stand burned-out cedar chimneys were seen; the bulk of all reproduction in this stand is that of Abies grandis, which is also well represented in other diameter size classes up to 22" dbh.

The high average basal areas for ponderosa pine and Douglas fir in gradient segments 2 and 3, are a consequence of the survival of a few of these pioneer species into the later stages of cedar-grand fir community development. The sizes achieved by these two species in the streamside habitats was not observed to be duplicated on any upland site examined during the summer of 1972.

Little need be said for Picea engelmannii. It is not uncommon in these communities, but rarely attains much dominance in numbers or size. The two largest Engelmann spruces measured during the study were 30" and 32" dbh; typically spruce averages much less than 20" dbh when encountered in these stands.

The data on dead snags and stumps (Table 2-H to 2-K) is provided only for redcedar and grand fir. These were the most commonly encountered, although snags and stumps were seen of all other conifers too. Redcedar standing snags and stumps average less than one (1.0) in nearly all of the gradient segments. I cannot recall ever seeing any great number of redcedars in these mortality conditions. The average basal area of the snags and stumps does show a close correlation with the moisture gradient segments.

Abies grandis stumps occur with the same low frequency as redcedar but grand fir standing snags are signifantly higher than cedar (Table 2-H).

It is my recollection that dead standing grand firs are common among the forest communities studied. These reach a high number in stands where grand fir is particularly dense (gradient segments 3 and 4). These are not always small sapling-sized grand firs that are seen in the dead condition, but often range in the 8-10" dbh size class. Grand fir stumps were most common in segments 2and 3, and these exhibited diameters generally between 10-15" dbh. Included in this stump category were individuals that were snapped off between the lower third and upper half of the stem length. Abies grandis is troubled by the fungus Echinodontium tinctorium, which may enter through the dead lower limbs or through frost cracks (a common sight in these wilderness communities). The resulting heart rot is evidently a major cause of the observed mortality (increment boring was generally impossible beyond the sapwood layer in many of the trees tested) and stem breakage.

The final set of data in Table 2 (2-L) illustrates the average number of trees, per species, less than 4.5 feet in height, within the smaller, 50 m^2 subplot. The data reveal a similar pattern as that shown in Table 1. It would appear that the roles of major climax and minor climax and co-climax for Thuja and Abies can best be described as gradational phenomena. The plot data were taken from rather restricted portions of each community, and the area encompassed by each plot was in each case rather uniform in its features. Both species appear capable of existing and reproducing themselves within the moist and mesic segments of the gradient. THIS CONCLUSION HOWEVER IN NOT ENTIRELY CORRECT!!!

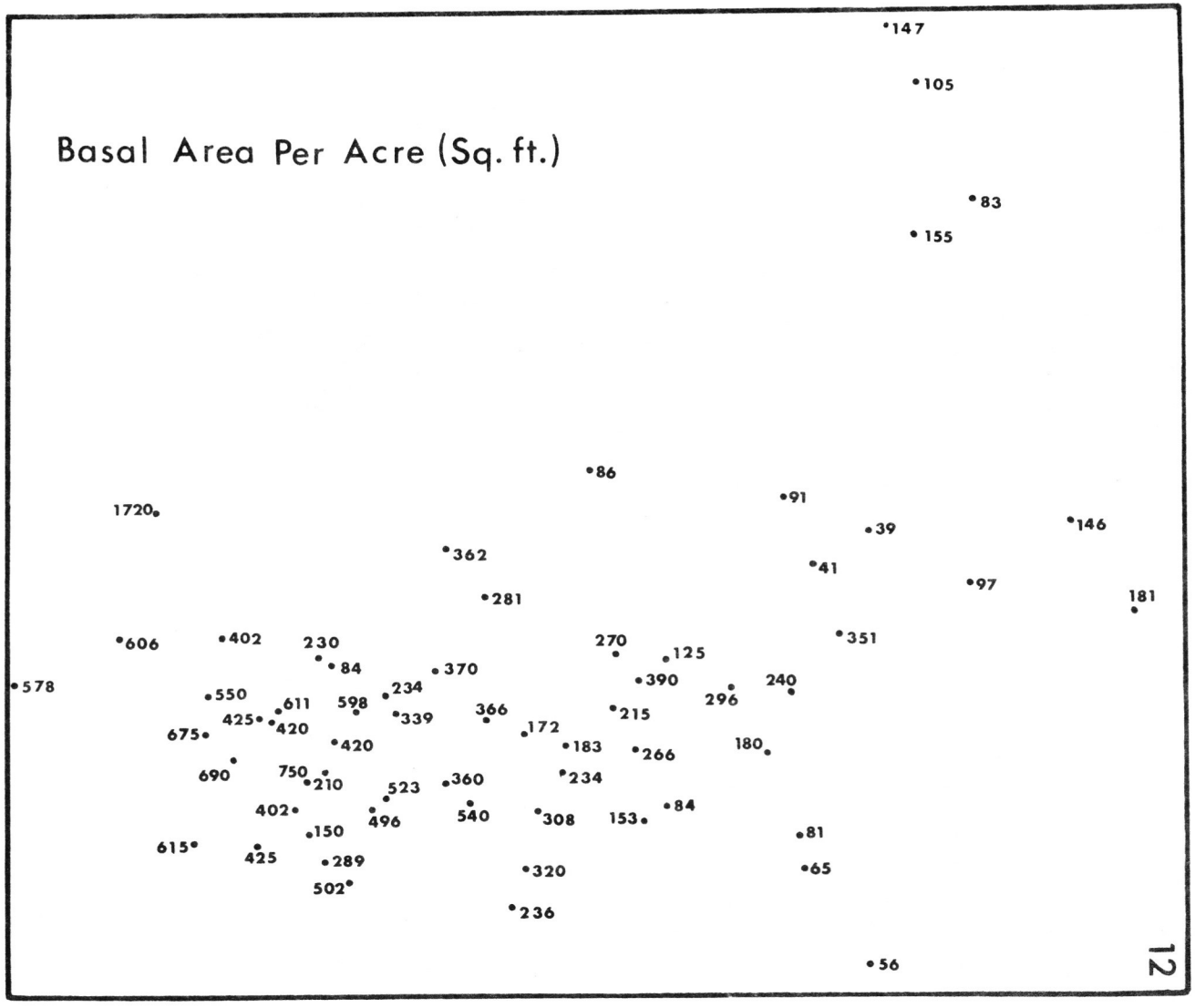
In examining Fig. 3 (Geographical locations of stands within the ordination) and Fig. 6 (Coverage of Thuja plicata under 4" dbh) it is noted that among the stands on the left hand side of the ordination...

those dominated by Thuja plicata and Abies grandis (gradient segments 1 and 2 basically)...the stands that exhibit conspicuous amounts of redcedar reproduction are those confined to the Upper Moose Creek/ Upper Lochsa River areas. Similar stands (similar in coverage for larger tree sizes) on the lower Moose Creek, and lower Lochsa, display a near absence of redcedar reproduction. A comparison of these two geographical regions is given below: Values are average % cover:

Species	Lower Bear Creek Lower Moose Creek Lower Lochsa River (13 Stands)	Upper Moose Creek Upper Lochsa River (12 Stands)
Thuja plicata: Over 12" dbh	48.3%	47.9%
4-12" dbh	9.1	10.4
Less than 4"dbh	0.6	21.8
Abies grandis: Over 12" dbh	6.7	2.7
4-12" dbh	18.3	7.8
Less than 4" dbh	9.3	12.6

With the exception of Thuja reproduction the communities in these two areas do not show great compositional differences. The position of all of these stands in the same portion of the ordination does reflect a high degree of compositional similarity, including both tree and understory flora. Generally the Upper Moose Creek and Upper Lochsa River stands are classified as members of the Thuja plicata climax series, and the Lower Moose/Lower Lochsa, with some exceptions (stand 11, for example) are classed within the tentative Thuja (Abies) climax series. The possible causes of these differences in upper and lower stations along these drainages will be the subject of later discussion.

Figure 12 provides some further reinforcement of the data presented in Table 2. Here the total stand basal area, expressed in square feet per acre, has been plotted within the ordination. The highest basal area values occur among the redcedar-dominated stands, particularly the ancient cedar groves such as the DeVoto Memorial Cedar Grove and the groves along the upper Moose Creek drainage. The values show a gradual reduction of basal area among the drier grand fir and Douglas fir communities. The gradation from high to low basal area totals is not entirely perfect however. Among the cluster of communities that compose the Thuja (Abies) climax series a rather spectacular range of differences can be seen; some the lowest totals are below 100 square feet per acre, while the highest are 500-700 square feet per acre. Among the Abies grandis climax series, this range is from well below 100 square feet per acre, to over 300 square feet per acre. These difference appear to be related to stand age mostly; the ordination does not reveal successional gradients clearly. Although some young stands were sampled in the Cedar-Abies and Abies series, together with intermediate and old-aged stands, these were not spatially separated very well, if at all, in this ordination. This is because the young, intermediate and old-aged cedar and cedar-grand fir stands have very similar understory, compositional features; that is, coverage values for shrubs and herbs are very similar among the different aged communities. It may be an over-generalization to state this, but it seems that the understories characteristic of these mesic cedar and cedar-grand fir communities become re-established within the early stages of recovery, following disturbance, and major changes do not occur after a century of recovery.


Basal Area Per Acre (Sq. ft.)
147
105
83
155
86
91
1720
39
146
362
41
97
281
181
606
402
230
84
370
270
125
351
578
550
611
598
234
390
240
296
425
420
339
366
215
675
172
420
183
266
180
690
750
210
523
360
234
402
496
540
308
153
84
150
81
615
425
289
320
65
502
236
56
45
12

Many of the same species of herbs, with many displaying similar percentages of cover, can be found in both century-old stands and in stands 300-500 years old. If a great number of youthful stands in the cedar and cedar-grand fir series could have been available for sampling (stands 10-50 years of age), compositional differences related to time (succession) might have emerged within the ordination. In other words, the youngest stands in general are still "too old". A check was made of pairs of stands, near one another in the ordination, but having grossly different total basal areas per acre; in the cases checked, stand compositions were very similar (herb and shrubs, kinds and amounts).

A summary of other stand features tabulated involved averaging the depths of soil layers (L, F, and H) and tree, shrub and herb heights. The L layer in gradient segments 1-5 ranges from 3.0-3.5 cm, and is reduced to an average of 1.7 cm in segment 6. The F layer average depths are between 3.5 to 4.5 in segments 1 and 2, but is between 1.0 to 2.5 cm in segments 4-6. The H layer depth averaged 7.2 cm in segment 1, and gradually becames reduced in successive segments (6.5, 5.2, 3.8, 2.6, and 1.1 cm) of the gradient.

Stand heights average 83-92 feet in segments 1 & 2; 72-76 feet in segments 3 & 4; 61-72 in segments 5 & 6. Shrub heights are variable, although they average less than 1.0 feet in segment 1, and 5.6 feet in segment 6. The intermediate segments of the gradient ranged between 2.8 and 3.5 feet. Herb heights are highly similar in all segments; the range is between 1.2 feet (segment 2) and 1.8 feet (segment 6).

Understory Species: Summarized data for the most common understory species are provided in Table 3. Here the mid-points of the coverage classes (page 10) were averaged together for each species within each of the six compositional gradient segments. A number of the understory species were selected and their coverage class values plotted within the ordination (Figs. 13-22). The species in Table 3 have been arranged to emphasize the shifts that occur between the moist gradient segments and the drier ones. The first ten species listed attain their highest coverage values in the moist redcedar and redcedar-grand fir dominated communities. There is another set of species that achieve their highest values in the cedar-grand fir and grand fir dominated stands. This gradual compositional shift continues through this table of data, ending with species that are most abundant, and sometimes markedly restricted, to the stands dominated by Douglas fir and ponderosa pine.

The number of species restricted to segments 5 and 6 is rather limited because a total sample of species was not possible at the end of August; a great number of the understory species on the warmer, upland slopes are best tabulated in June when they are in full development. Coverage estimates are also subject to variation in such communities, when sampled at the end of the summer.

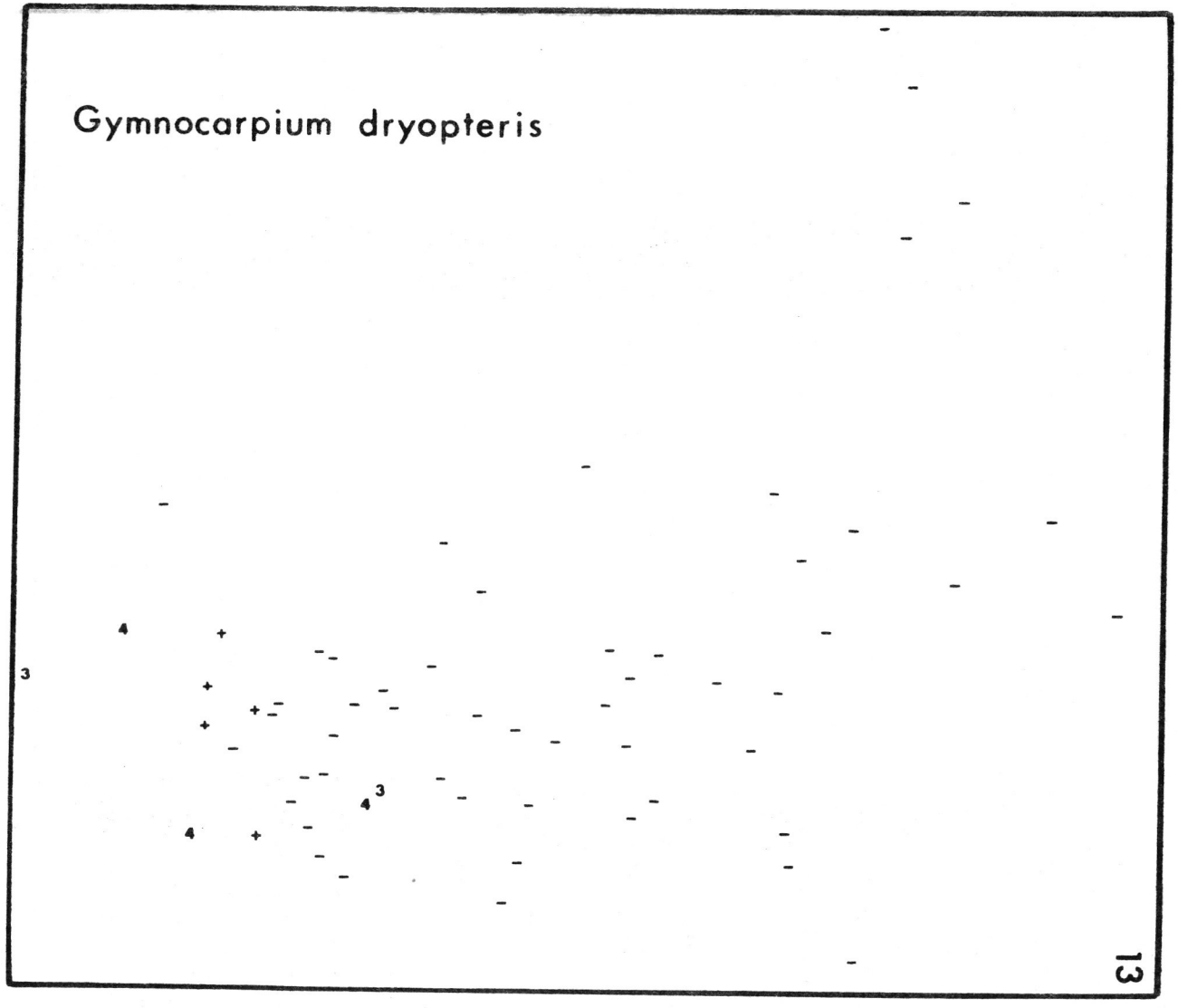
Collectively the arrangements of the coverage data in Table 3 support the view that a vegetational continuum exists, closely related to a moisture gradient. Each of the forest climax series does not have a uniquely different assemblage of understory species; and certainly the various habitat types are not compositionally discontinuous from one another. The continuity that exists is further emphasized by the

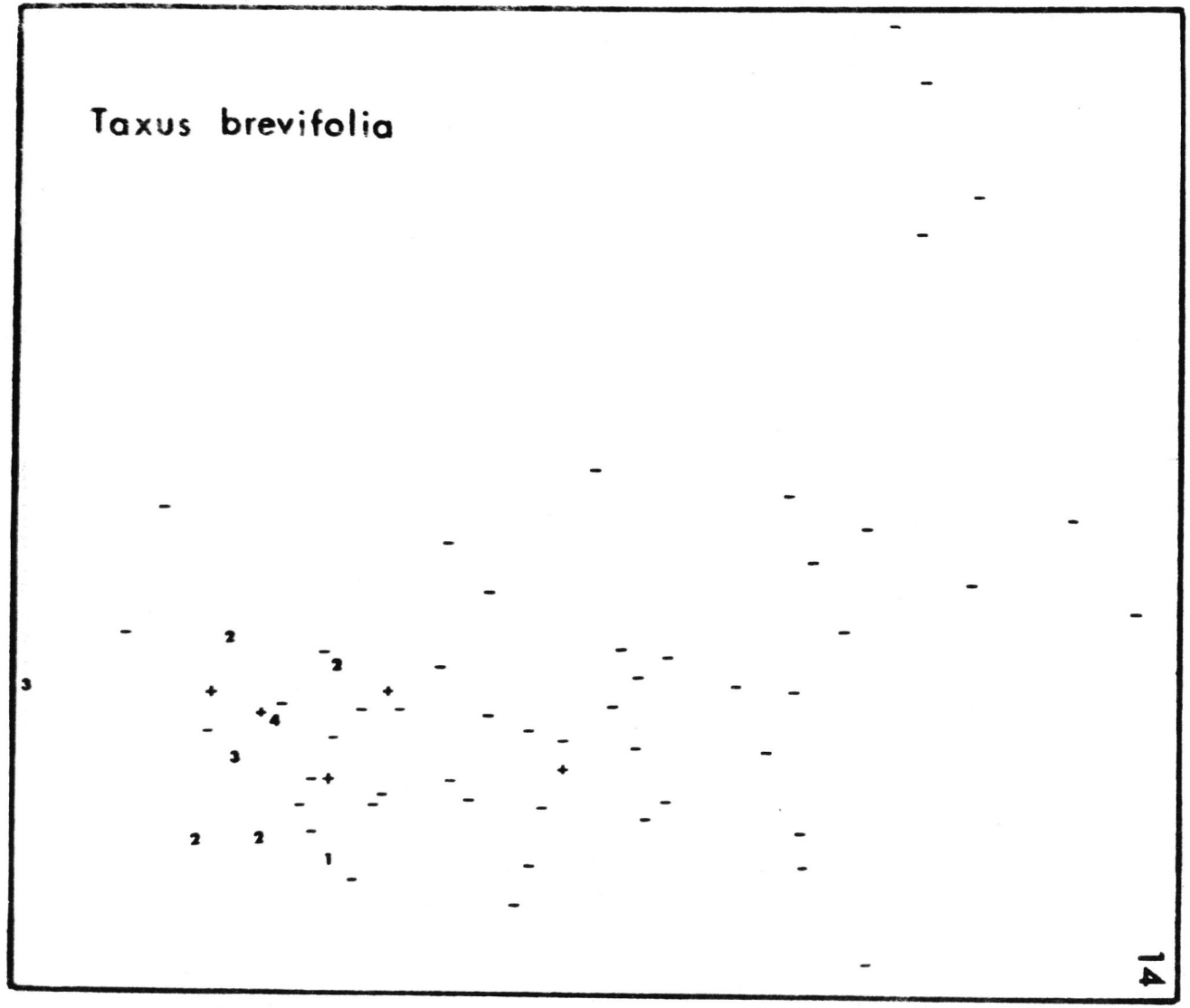
Table 3. Average percent cover for a series of understory species within each of six compositional gradient segments (primary ordination axis). t = average less than 0.5%.

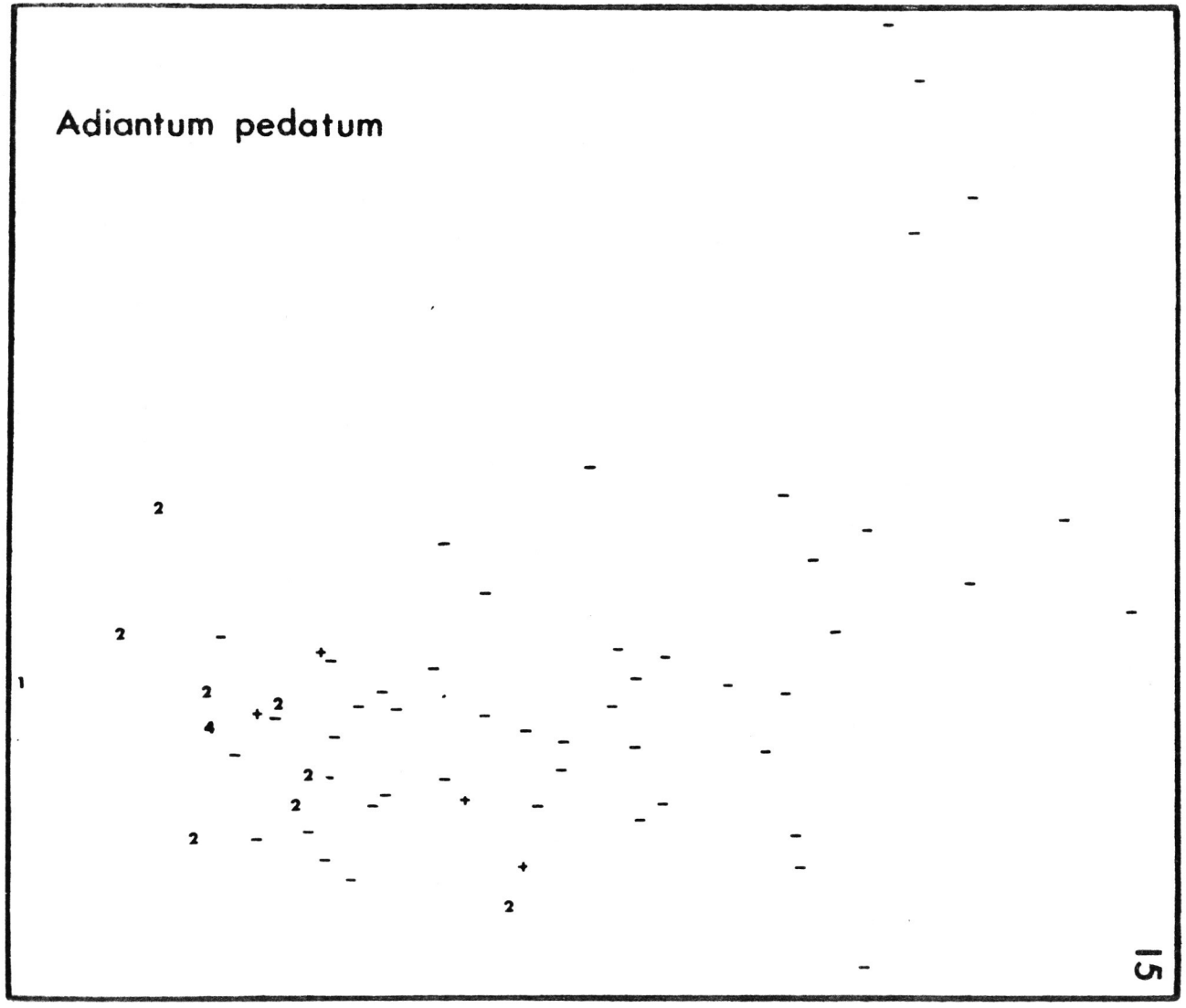
Species	Compositional Gradient Segments					
	1	2	3	4	5	6
Circaea alpina	53	4	0	0	0	0
Botrychium virginianum	t	t	0	0	0	0
Asarum caudatum	26	8	7	0	0	0
Adiantum pedatum	21	2	1	0	0	0
Athyrium filix-femina	19	1	1	0	0	0
Trautvetteria caroliniensis	11	4	t	0	0	0
Taxus brevifolia	9	7	t	0	0	0
Senecio triangularis	4	2	t	0	0	0
Dryopteris filix-mas	t	t	t	0	0	0
Vaccinium caespitosum	0	t	1	0	0	0
Tiarella unifoliata	8	12	3	t	0	0
Cornus canadensis	1	10	3	2	0	0
Smilacina stellata	9	8	6	6	t	0
Trillium ovatum	3	3	1	t	t	0
Polystichum munitum	1	t	t	t	t	0
Coptis occidentalis	28	37	28	8	7	0
Linnaea borealis	1	26	19	8	5	0
Clintonia uniflora	4	17	10	7	6	0
Xerophyllum tenax	0	4	t	2	t	0
Goodyera oblongifolia	t	2	1	t	t	0
Chimaphila umbellata	t	3	5	t	t	0
Pedicularis racemosa	0	1	3	t	t	0

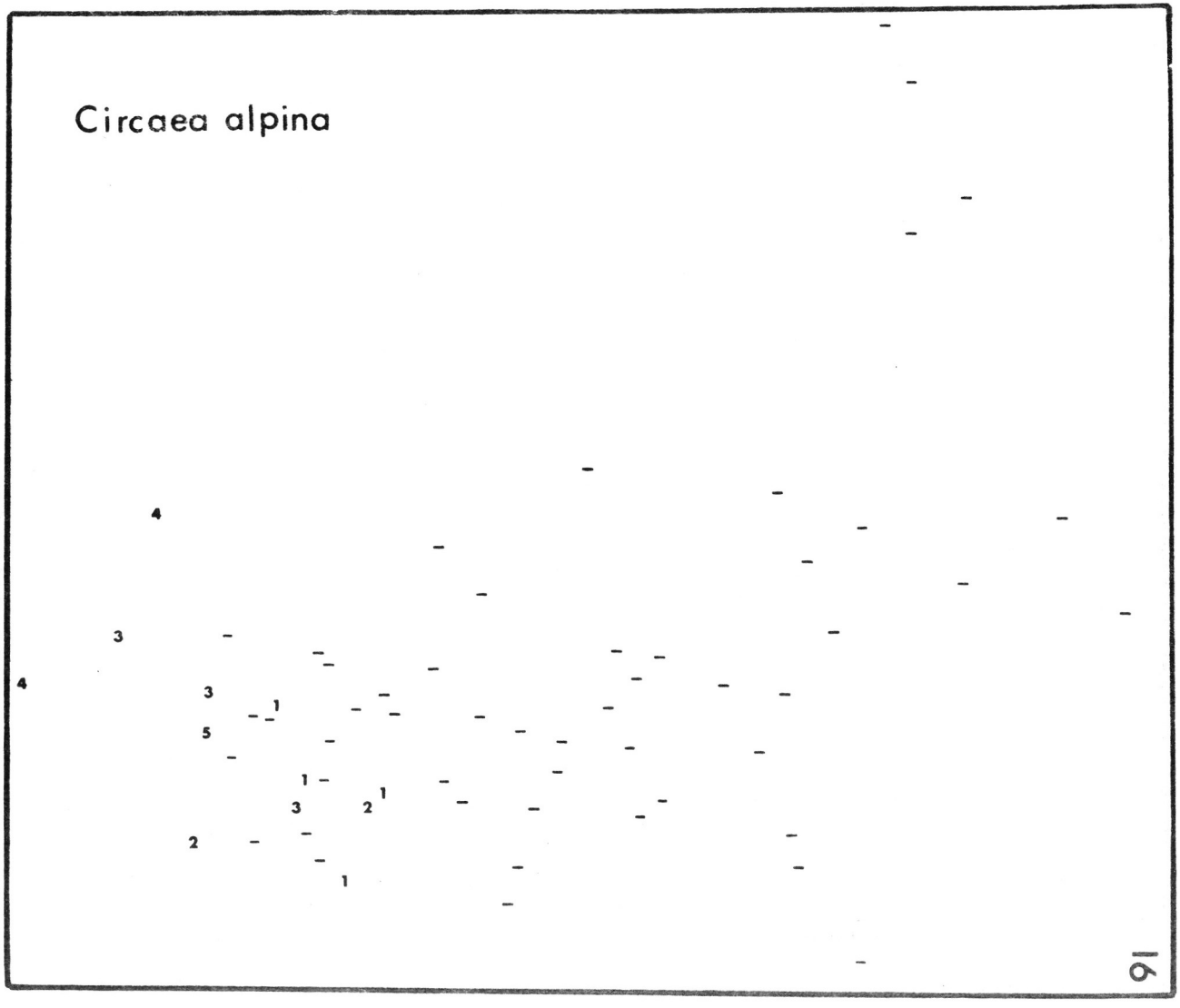
Table 3 (continued)

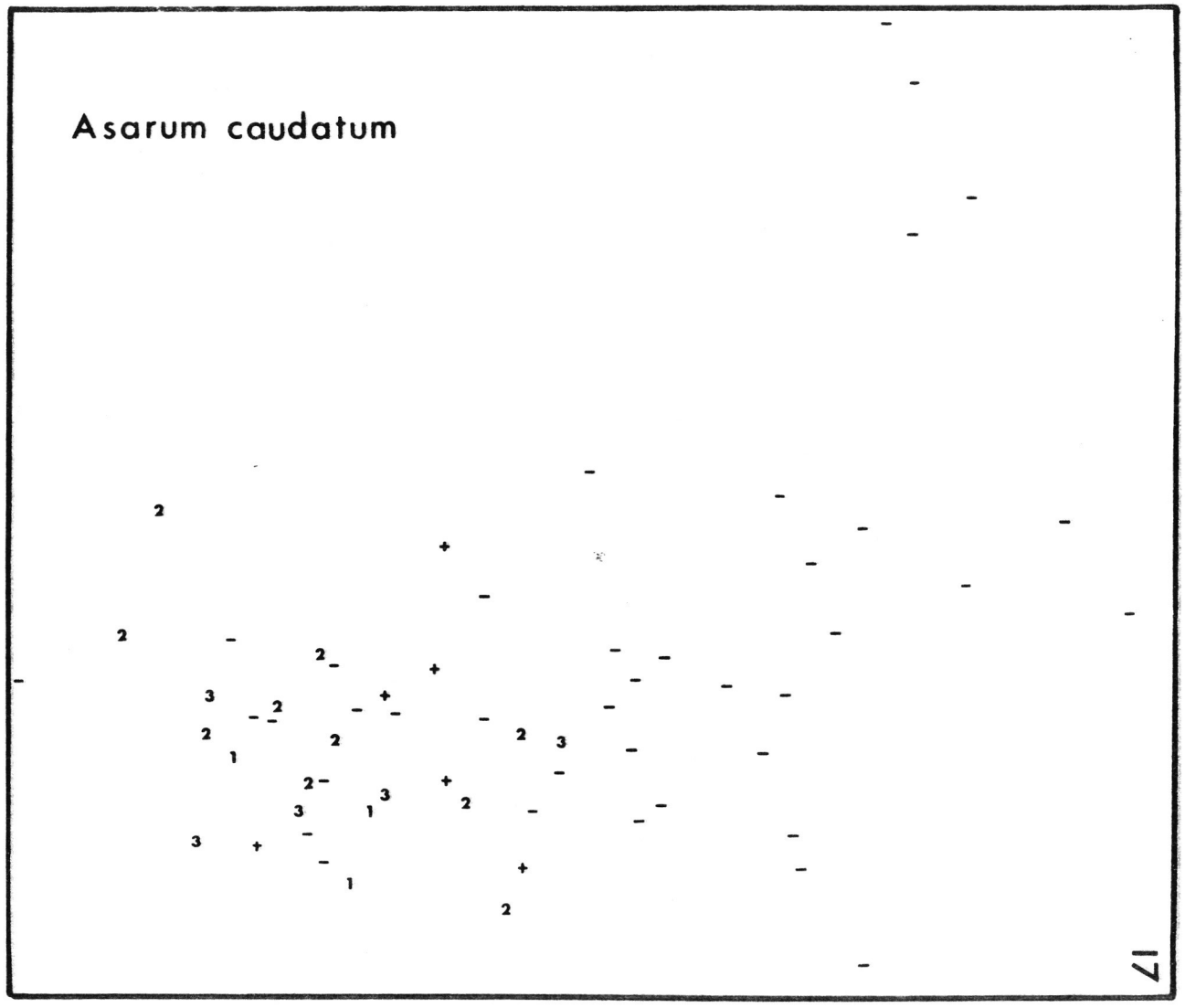
Species	Compositional Gradient Segments					
	1	2	3	4	5	6
Anemone piperi	1	2	2	1	t	t
Rubus parviflorus	t	2	6	3	1	t
Adenocaulon bicolor	7	7	8	7	t	t
Rhamnus purshiana	1	1	2	t	0	t
Disporum hookeri	6	12	12	13	5	t
Acer glabrum	t	2	1	10	2	t
Vaccinium membranaceum	1	1	2	6	4	1
Arnica cordifolia	t	1	2	7	21	t
Rosa gymnocarpa	1	4	6	4	8	2
Silene menziesii	t	t	1	4	6	1
Symphoricarpos albus	t	2	3	6	10	30
Holodiscus discolor	t	t	t	5	3	13
Fragaria virginiana	t	t	2	1	2	8
Spiraea betulifolia	0	t	2	5	3	3
Ligusticum verticillatum	0	t	t	6	6	16
Philadelphus lewisii	0	2	4	6	1	17
Campanula rotundifolia	0	0	0	t	3	1
Achillea millefolium	0	0	0	t	1	1
Agropyron spicatum	0	0	0	t	3	11
Balsamorhiza saggitata	0	0	0	0	4	9

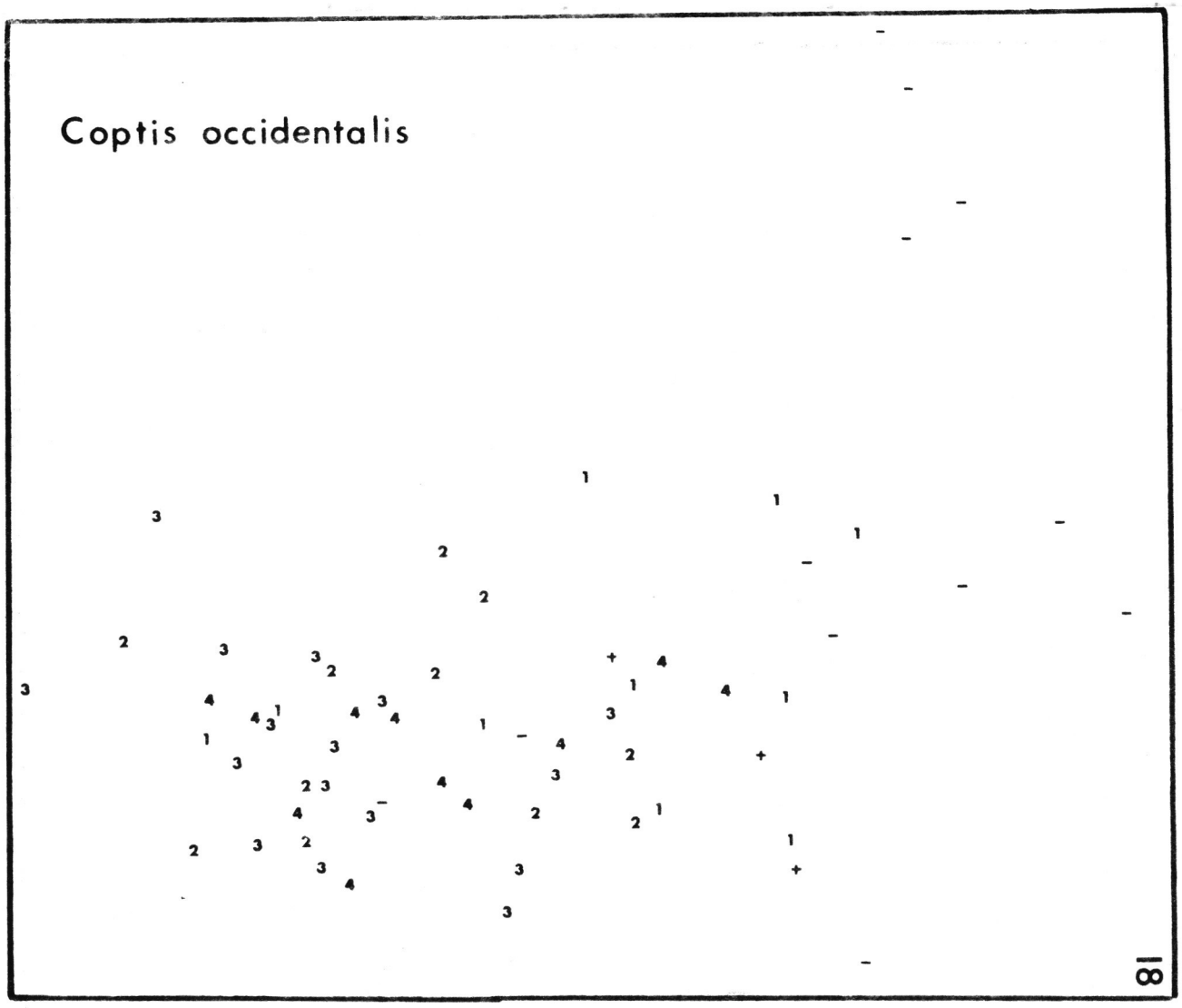

Gymnocarpium dryopteris
50
13

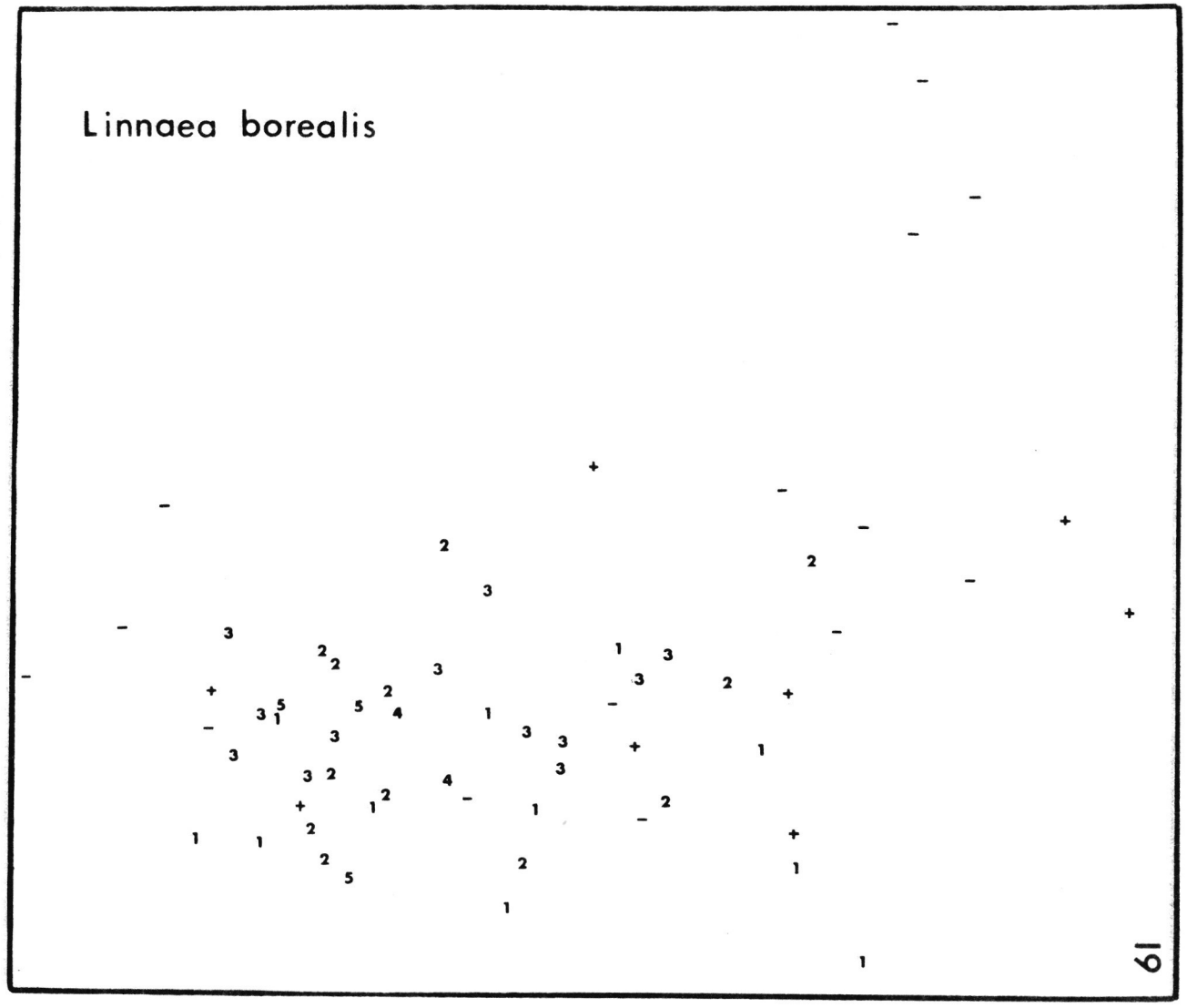

Taxus brevifolia
14


Adiantum pedatum
52
15


Circaea alpina
16


Asarum caudatum
54
17


Coptis occidentalis
18

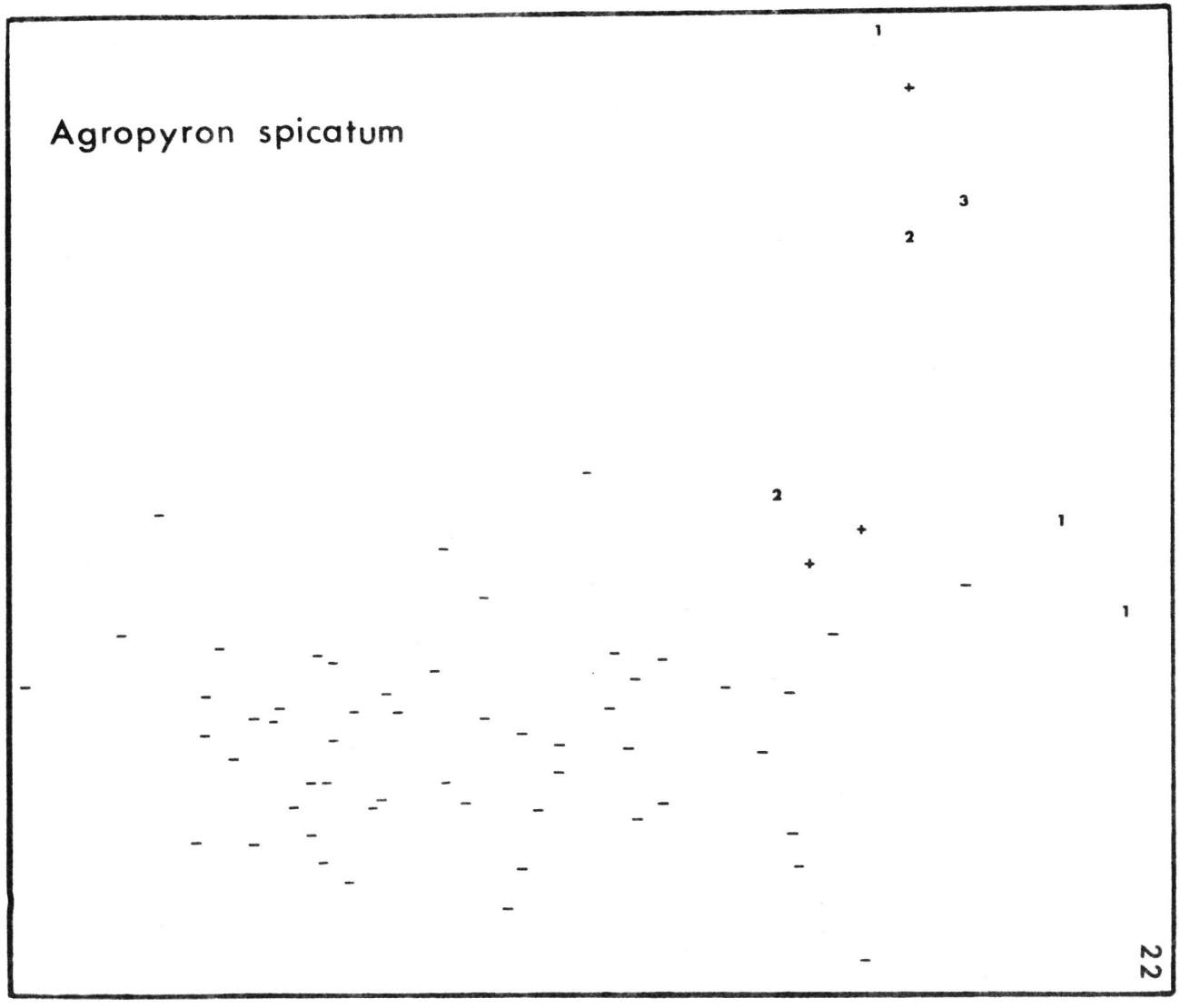

Linnaea borealis
19

Clintonia uniflora
57
20

Arnica cordifolia

58

21


Agropyron spicatum
22

patterns of coverage values for the species plotted in Figs. 13-22. No two patterns are exactly alike; each demonstrates a range of occurrence and range of cover values that is different. Sets of species do occur within the wet, mesic and drier portions of the ordination, but even within these sets, differences are discernable. These data offer further support to the idea that these communities, many of them old-aged, are affected compositionally by their position along a complex environmental gradient.

Three species: Coptis occidentalis, Linnaea borealis and Clintonia uniflora are among the most commonly encountered understory species in the cedar & grand fir communities; the complete absence of any of these three species in such stands was rare. Arnica cordifolia and Agropyron spicatum achieve their highest values among the drier stands located in the righthand side of the ordination, yet it can be noted that these two species are clearly differentiated by the stand separation along the secondary (Y) axis. Arnica cordifolia appears to be closely related to the "driest" grand fir communities included in the 63 stand sample, and the specific stands where this species achieved high cover values are currently mixtures of grand fir and Douglas fir. Agropyron spicatum is generally confined to the open, upland communities currently dominated by ponderosa pine and Douglas fir.

Comparison With Other Results: Vegetational analysis of the forest cover in the Selway-Bitterroot Wilderness (& Lochsa River drainage) has also been reported upon by Daubenmire and Daubenmire (1968). Based on field plot samples similar to those employed in my study, the work of the Daubenmires can be compared with mine, and thus can be the basis for further interpretative remarks here.

This comparison will concentrate on the information and plot data published by the Daubenmires for the Abies grandis-Pachistima myrsinites habitat type and for a portion of their data within the Thuja plicata series. A semi-outline form will be employed here to facilitate this discussion:

1. "The Abies grandis-Pachistima association has Abies grandis as the sole dominant of the tree layer."

2. "Among trees in near-climax stands of A. grandis-Pachistima forest, Picea engelmannii is second only to the Abies in vitality."

3. "The most common seral tree, but one distinctly less able to maintain its population in the Abies h.t. is Pseudotsuga."

4. " The paucity of small- and medium-sized individuals (of Thuja) in old Thuja plicata-Pachistima (h.t.) stands is notable."

5. "Abies grandis is but slightly less successful than Thuja where the two compete in the Thuja-Pachistima h.t. and is usually not eliminated between successive catastrophic fires on the same site."

6. "However, since its [Abies grandis'] reproduction is definitely more discontinuous than that of Thuja, and Thuja stands can be found that are entirely free of Abies, the Abies is best considered a long-lingering seral species."

7. "Some trees are almost climax in certain h.ts.(e.g., Abies grandis in the Thuja-Pachistima h.t.....). Thus we find a gradient connecting species that are invariably seral (e.g. Larix occidentalis) to those that are invariably self-reproducing wherever they occur (Tsuga heterophylla)."

8. The data collected in this study seem to indicate the occurrence of Thuja-dominated stands wherein this species is reproducing well (Upper Moose and Upper Lochsa areas), and other Thuja-dominated stands where this is not occurring (lower Moose, lower Lochsa, lower Bear Creek).

9. There are stands jointly dominated by Thuja and Abies in the Selway-

Bitterroot Wilderness that presently display good Abies grandis reproduction, but a near or complete absence of Thuja plicata reproduction.

10. There are stands in the wilderness area that are clearly old-aged and dominated by Abies grandis, but Thuja is only a minor component.

11. It would appear that the one observation or interpretation made by the Daubenmires ,#7 above, fits the dynamic situation reflected in the wilderness data. Both grand fir and western redcedar would occupy mid-point positions on the "gradient of competitive potential" (Daubenmire and Daubenmire, 1968, p 55), and neither one or the other is invariably seral or climax in situations of joint occurrence, in all parts of northern Idaho.

We are left with the necessity of explaining, if possible, the differential reproductive capacity of Thuja plicata in the Moose Creek and Lochsa River drainages, that has been mentioned earlier. At this point it might even be mentioned that the three streamside, Thuja-dominated stands on the lower Bear Creek drainage (stands 32,33 and 35) display little or no cedar reproduction, as the lower Moose and lower Lochsa sites.

The upper Moose Creek and upper Lochsa River areas do receive more precipitation annually than do the lower regions on these drainages; the elevations are somewhat higher, and much more of the annual precipitation is in the form of snow. The upper drainage sites not infrequently exhibit an actual tangle of cedar reproduction; it is believed that deep snow packs flatten young cedar trees to the ground, and in this position they can reproduce vegetatively. Rows of side branches may be observed reorienting themselves upward, while the limbs on the lower sides give rise to adventitious roots.

Broken cedar limbs can also initiate new saplings. The origins of 2-3" dbh saplings in the upper Lochsa have been checked by excavation, and generally the vegetative origins can be detected.

Moisture on the lower reaches of the Bear Creek, Moose Creek and Lochsa River drainages is lower, although annual precipitation does reach 40" or more. Compared with moisture levels in Glacier National Park and elsewhere where redcedar has been observed to be reproducing itself, the wilderness areas not giving rise to cedar reproduction seem to be as moist. The snow packs are not as great at these lower drainage sites however, and this might be a critical feature in the successful regeneration of the cedar. The sexual reproduction of redcedar is not highly shade tolerant (Habeck 1968); vegetative reproduction is more capable of surviving in dense shade.

The lack of sufficiently deep snow packs might hinder cedar reproduction in portions of the wilderness area, and sexual reproduction is not effective as an alternative. The cedars that occur on the lower reaches of these wilderness drainages do represent stations very near the southern and/or southeastern range limits for this species. Thuja's common companion species western hemlock (Tsuga heterophylla) does not occur in the wilderness; even other associates such as western larch (Larix occidentalis) and western white pine (Pinus monticola) are extremely rare. Thus there are climatic/geographic factors that enter the ecological picture of redcedar in the study area.

The Pacific Coastal floristic elements were more wide spread in the past than they are today (Daubenmire 1943). With the rise of the Cascade Mountains to the west, penetration eastward of moisture laden air masses became reduced. What one sees today, as one point in phytogeographical time, are plants and are in different stages of retreat from a former, wider range in the northern Rocky Mountains.

Thus one explanation of what is happening to Thuja plicata is that

this species is or has encountered environmental limiting factors at the edges of its botanical range. The tree is long-lived; it has been estimated that it may live to 1000 years (Daubenmire and Daubenmire 1968) Climatic changes over a period of hundreds of years may not be reflected with any great rapidity in the populations of such a species. When the influence of limiting factors is expressed, it is not unlikely that the reproductive components are affected first. The study areas are not near the range limits of Abies grandis, thus this species may be in the process of gradually replacing cedar on the lower drainage sites (Figs 23-24). If redcedar is indeed "retreating" from its former range limits, one would not expect that the tree literally to move westward, but rather to shrink its range "upstream" and become confined to suitably moist sites. One of the last relict populations of Thuja known to occur southeast of Missoula, occurs at an elevation of about 4000 feet in the upper reaches of Miller Creek.

Another conifer that has been studied on its eastern range limits in western Montana is mountain hemlock (Tsuga mertensiana). This tree appears to maintain its capability to reproduce itself even at its present range limits. The sexual reproduction of this hemlock is very shade tolerant however, in contrast to redcedar.

More field work might be done to substaniate the ideas described above. The competitive relationships between grand fir and redcedar are not entirely clear cut in areas of Idaho north of the Selway-Bitterroot Wilderness, and the confusion in discriminating between grand fir climax types and cedar climax types (=the habitat typing efforts) would only be increased when dealing with communities near the range limits of cedar.

Another idea that might also be tested by additional field work involves the possible influence of big game species (deer, elk and moose) on cedar

64a

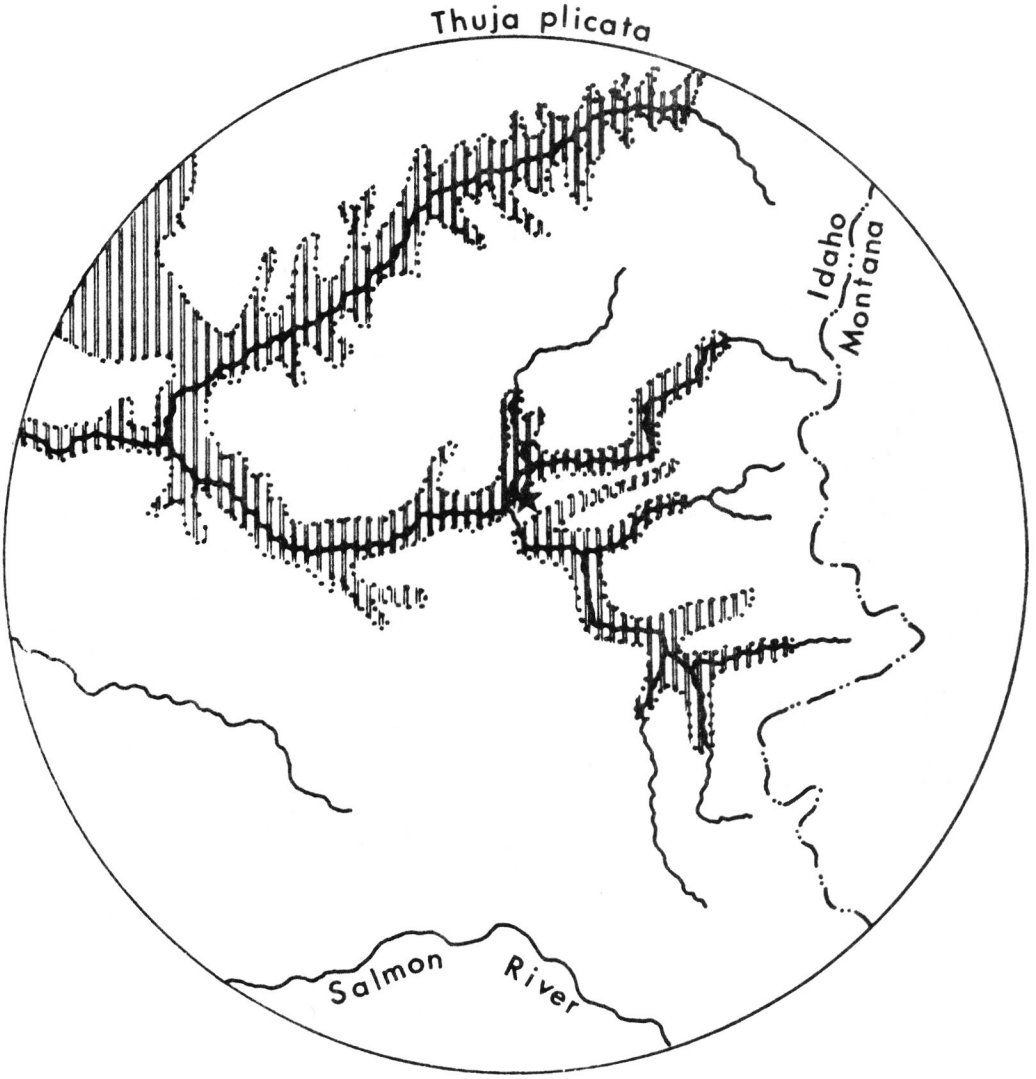


Fig 23

64b

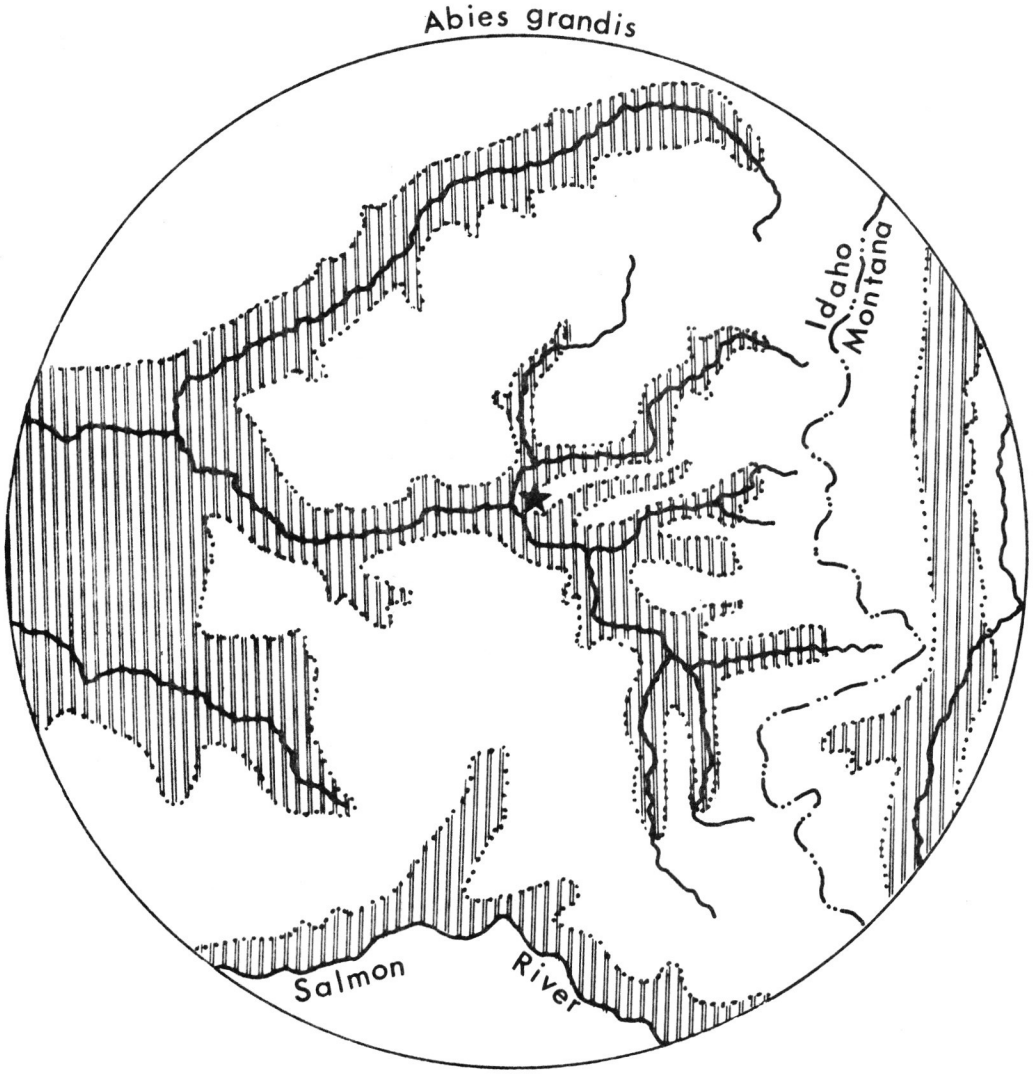


Fig 24

reproduction on the lower Bear Creek, Moose Creek and Lochsa River drainages. If winter snow packs, or early spring residual snow packs, are significantly less on the lower segments of these drainages, as they are thought to be, big game utilization of cedar reproduction might be (or might have been) sufficient to cause the loss of the sapling layers... and thus simulate the same conditions that have been described in the case of climatic changes. It is difficult to imagine the high degree of efficiency involved with big game removing the cedar reproduction from three geographically separate locations. Even the most heavily used winter deer yards in northern Wisconsin (Habeck 1960), which are lowland white cedar (Thuja occidentalis) swamps, do not display such a cedar reduction as appears to be the case in these areas in northern Idaho.

If big game animals have indeed been a major influence in this situation, then the habitat-typing efforts might require readjustments. It has not even been suggested up to this time whether fire, its presence or absence, has anything to do with this redcedar situation. Excellent stands of redcedar have been established following fires in Glacier National Park, and this has been the result of successful sexual reproductive processes. If vegetative reproduction is failing in parts of the wilderness, and adjacent areas, this does not mean that redcedar could not become re-established after fires in these same areas. More field work could shed light on this aspect, but if there is any truth in this idea, it still would require an altered view of the climax status of redcedar at its range limits.

Species Diversity and Equitability: The data in Table 3 are useful in an explanation of species behavior along the ordinational gradient. Only those species that are relatively common in one or another of the six segments are included in this table; it gives only an approximation of the differences in species diversity among the segments. Ecologists are generally interested not only in the number of different kinds of species that compose plant communities, but also in the abundance of each kind of species. This latter feature is referred to as "species equitability." For example, two communities may each have five species, and a sample from each community might indicate that there are a total of 100 individuals present. In one community these 100 individuals may be equally divided among the five species: 20-20-20-20-20; the second community might have a distribution such as: 96-1-1-1-1. Both stands have identical species diversities (five different species), but the equitability is much greater (in fact maximum) in the first stand, and least in the second case.

The plot data collected in this study does not provide estimates of numbers of each kind of plant species; only a cover estimate within the 375 m^2 area was tabulated for each species. One of seven cover classes (T, 1, 2, 3, 4, 5, or 6) was assigned. No species was in fact ever assigned a cover of "6", and cases where "5" was assigned to understory species were rare. In analyzing the plot data it was noted that many examples exist where two stands had similar or even identical species diversity, but the distribution of the species within the various cover classes differed markedly; at other times equal diversity was matched by similar equitability.

Examples of the above can be briefly outlined. Stands 4 and 15

both contained a total of 29 understory species (herbs and shrubs). The distribution of these 29 in stand 15 (in order of the cover classes, T-6) are as follows: 10-10-6-1-2-0, where as in stand 4 the arrangement was: 27-2-0-0-0-0. In the second example, stands 45 and 52 both have a relatively low species diversity, amounting to 17 species. The distribution of these within the cover classes are as follows: Stand 45: 7-5-3-1-1-0; and Stand 52: 6-9-1-0-1-0.

The range in species diversity is from 14 (stand 41) to 45 (stand 16). The arrangement of the species within the cover classes for these two stands is as follows: Stand 41: 5-4-5-0-0-0; Stand 16:17-14-10-2-1-1. When abundance or production data are available for each species in each community it is possible to construct what are called "species importance value curves" (Whittaker 1972). The curves resulting from this operation may take various forms. In examples cited by Whittaker, it appears that early stages of succession (pioneer) are characterized by low species diversity and a curve that is nearly geometric. Communities of later successional stages display greater species diversity, and the importance value curves approach a lognormal distributional character. When tree invasion occurs, diversity is reduced again (and curve is geometric). Finally when shade tolerant understory species enter the community, a secondary increase in diversity comes about (with curves becoming lognormal).

Table 4 was constructed to illustrate the average species diversity and equitability among the communities in each of the ordinational segments described earlier. Segment 6 was omitted here because the total flora in the drier communities could not be tabulated in August. In this table the average number of species within each of the five cover classes

Table 4. Species diversity and species equitability among the Thuja and Abies forest communities in the Selway-Bitterroot Wilderness. Data are presented for the first five compositional (ordinational) segments. The average number of species in each of six coverage classes, plus total number of species/plot, are provided. The percentage in each coverage class, based on the average total number of species is also given. See text for further explanation.

Gradient Segments (No. 375m^2 plots) (Averaged)	Cover Classes and Mid-point Cover Percentages						Average Number of Species
	T (0.5%)	1 (3.0%)	2 (15.0%)	3 (37.5%)	4 (62.5%)	5 (85.0%)	
1 (6)	12.6 (47.4%)	6.2 (23.3%)	4.6(17.3%)	1.8(6.7%)	1.0(3.8%)	0.3(1.5%)	26.5
2 (19)	16.6 (50.7%)	8.7 (26.5%)	4.7(14.3%)	2.1(6.4%)	0.6(1.8%)	0.1(0.3%)	32.8
3 (13)	18.9 (56.4%)	8.5 (24.9%)	4.4(12.9%)	1.8(5.3%)	0.5(1.4%)	0 (0%)	34.1
4 (10)	18.3 (60.7%)	6.5 (21.6%)	3.3(11.0%)	1.9(6.3%)	0.1(0.4%)	0 (0%)	30.1
5 (11)	14.2 (55.5%)	6.9 (26.9%)	2.7(10.5%)	1.1(4.3%)	0.7(2.7%)	0 (0%)	25.6

(=0.5%, 3.0%, 15%, 37.5%, 62.5%, and 85% midpoints) was determined for each segment. In addition a relative percent value was calculated for each based on the average total number of species (for the first value: 12.6/26.5 = 47.4%).

The five segments reflect a moisture gradient, as explained earlier, and not a successional gradient. Segment 1 includes the older, streamside Thuja stands, and segment 5, the younger, drier, upland Abies-Pseudotsuga communities. The absence of early successional streamside stages of development, and the absence of old-aged upland stands hinders the attempt to duplicate the work reported by Whittaker (1972). Nevertheless, we see that differences do exist in this table of data. The older cedar stands have a low species diversity, but the species that are present are represented in all five cover classes. The number of species in the 0.5% cover class represent the lowest number and lowest percentage among the five segments averaged. Segment 5 also has a low species diversity (similar to segment 1) but the equitability is somewhat less.

The greatest number of species (highest diversity) occurs within segment 3, and include communities that are currently co-dominated by Thuja plicata and Abies grandis (Tables 1 and 2). The highest average number of species in the 0.5% cover class is also in this segment. Segment 4 plots averaged about 30 species, but over 60% of these species occur in the smallest cover class. Since very few of the stands included in the averaged values are really young (none that would be called pioneer in the sense of being 5, 10 or 25 years old), construction of importance value curves from these data would give curve shapes that are lognormal. If individual stands are picked out, however, geometric curves (or nearly

so) do result among some (Table 5 summarizes data for all stands), but still the majority of the individual stands are lognormal (Fig. 25).

This phase of the fire ecology research has barely been scratched, and will require more attention. The maintenance of biotic diversity (alpha and beta diversity) in wildernesses is a major objective. Such diversity should be taken to mean not only the number of different kinds of plants and animals sustained, but also the species equitability.

Diversity and species equitability vary in time and space. The data that have been collected up to this time allow for an interpretation of the variation in space... that is, along environmental gradients... but the variation related to time (successional gradients within each climax forest series) is still only poorly understood. It might be expected that within each of the climax series, that species diversity and equitability follow the pattern as described by Whittaker (1972) for a series of pioneer, seral and mature stands in a New York oak-pine forest.

If biotic diversity is viewed as a wilderness resource that is worthy of preservation, and if biotic diversity is related to burning events in the wilderness, then community structural features will continue to require our attention. We want fire to assume a more natural role in our wildernesses, but we will have to enhance our capability of explaining "why" this is specifically necessary. Detailed fuel loading measurements permit us to make predictions of the fire events that are likely to occur in various community types, under certain environmental conditions. We need this knowledge, but we must also want information on the specific consequences of fire... that is, what's being accomplished?

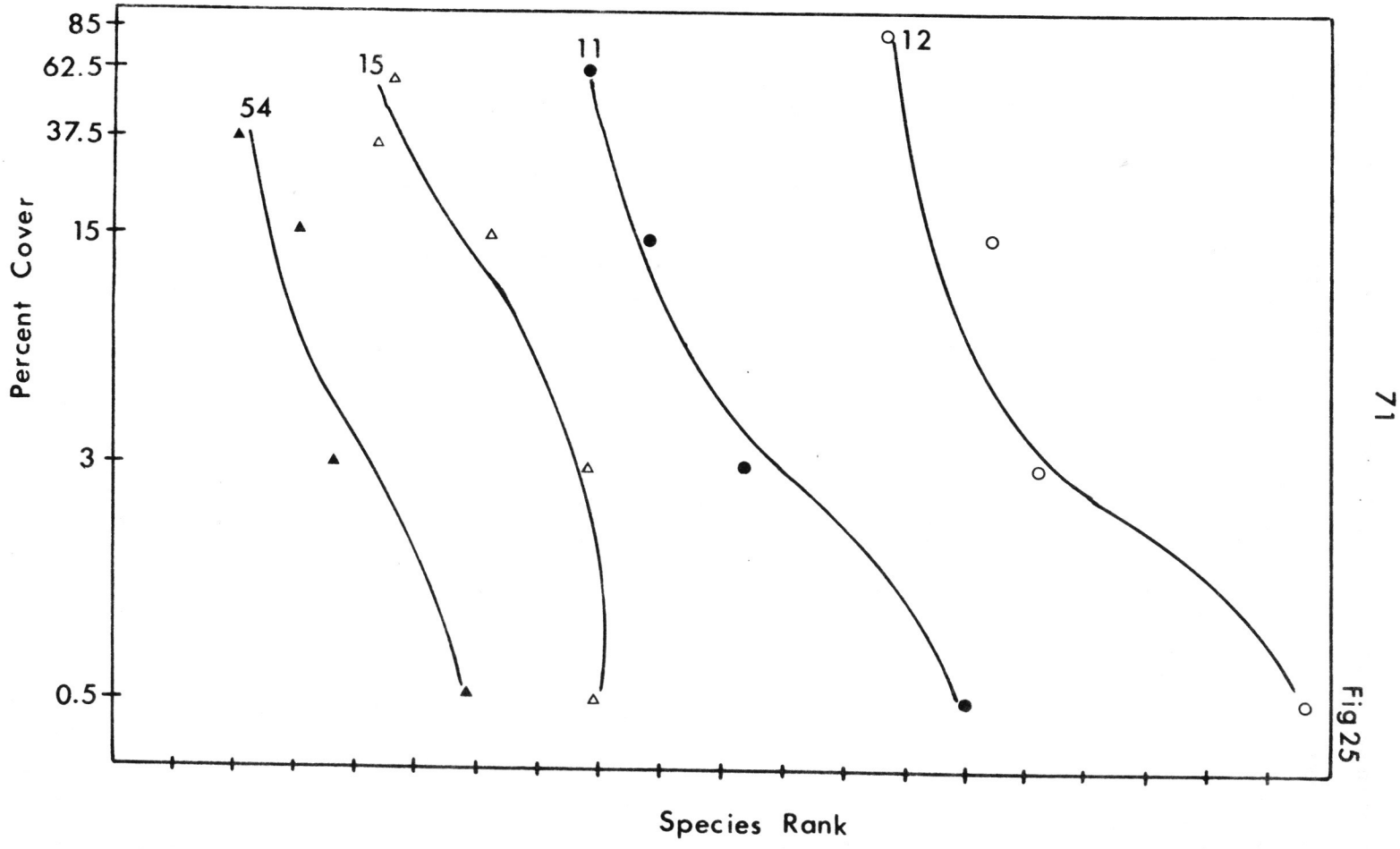


Fig 25

Table 5. Summer of species diversity information from the 63 study plots. The stands have been arranged from lowest total number of species to highest. Basal area (sq ft/acre) and tree densities (over 1" dbh) per acre are also provided.

Stand Number	Number Species	Cover Classes T	1	2	3	4	5	Basal Area	Tree Density
41	14	5	4	5	0	0	0	84	290
45	17	7	5	3	1	1	0	234	160
52	17	6	9	1	0	1	0	147	100
60	18	12	4	1	0	1	0	105	310
63	20	8	7	3	1	1	0	91	370
48	20	10	6	1	2	1	0	420	440
3	21	15	4	2	0	0	0	351	670
42	21	12	4	4	1	0	0	606	80
43	22	11	6	2	2	1	0	505	100
53	23	21	2	0	0	0	0	86	300
54	25	12	6	5	2	0	0	41	290
13	25	16	6	2	1	0	0	362	220
57	26	13	5	7	1	0	0	425	310
40	26	10	9	6	1	0	0	230	210
34	27	19	3	3	2	0	0	83	340
26	27	13	7	3	2	2	0	146	180
24	27	11	6	5	5	0	0	578	170
55	28	15	7	5	1	0	0	215	410
36	28	23	2	2	1	0	0	84	350
29	28	15	9	2	1	1	0	81	130
15	29	10	10	6	1	2	0	339	750

Table 5 (Continued)

Stand Number	Number of Species	Cover Classes T	1	2	3	4	5	Basal Area	Tree Density
1	28	22	5	1	0	0	0	240	650
62	29	15	9	4	1	0	0	370	310
4	29	27	2	0	0	0	0	270	270
58	30	11	9	6	4	0	0	39	420
59	30	13	11	4	1	0	0	125	460
10	30	16	8	4	2	0	0	266	260
6	30	18	6	4	0	2	0	540	320
2	30	22	6	1	1	0	0	395	330
14	30	18	8	2	3	1	0	425	300
12	31	18	7	5	0	0	1	611	160
61	31	14	14	2	1	0	0	281	330
51	31	18	7	2	4	0	0	402	340
37	31	23	3	3	1	1	0	65	230
38	31	13	8	5	3	2	0	56	100
28	32	14	10	5	3	0	0	180	290
50	32	20	7	4	1	0	0	289	540
11	32	17	8	4	0	2	1	675	80
47	32	16	7	7	2	0	0	210	250
8	33	24	7	1	1	1	0	360	260
27	34	18	10	3	3	0	0	155	130
56	34	24	6	2	2	0	0	320	200
39	35	15	8	8	3	1	0	236	240
31	35	18	8	5	4	0	0	153	350
18	35	12	8	8	6	1	0	183	320
22	35	21	8	4	1	0	0	308	220

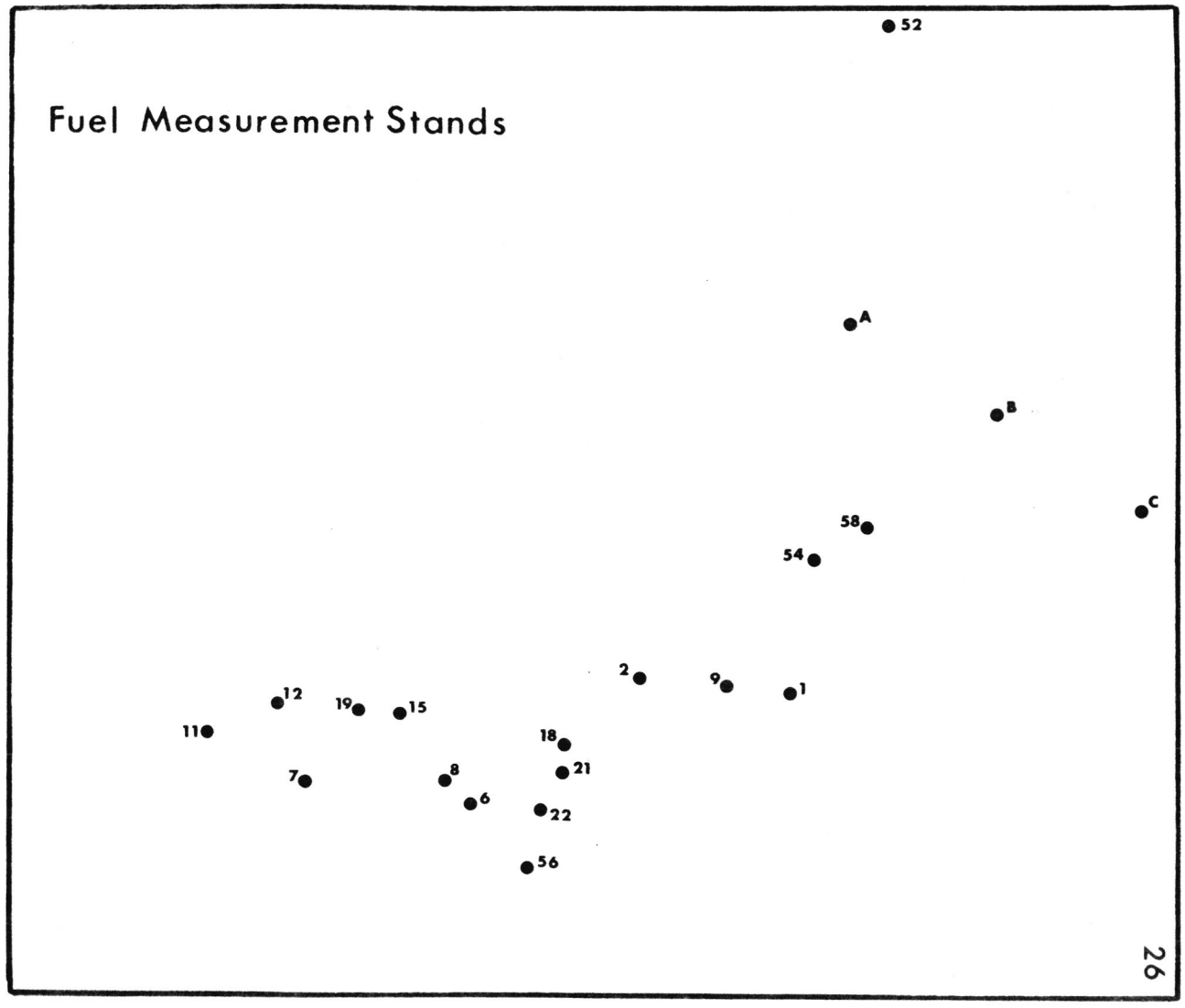
Table 5 (Continued)

Stand Number	Number of Species	Cover Classes T	1	2	3	4	5	Basal Area	Tree Density
44	35	24	7	2	2	0	0	234	160
9	36	16	11	5	3	1	0	296	570
25	36	21	11	3	1	0	0	181	160
49	36	23	6	2	5	0	0	690	390
5	37	26	7	2	2	0	0	420	250
20	37	13	9	8	3	3	1	502	330
30	37	23	9	2	3	0	0	97	180
33	39	18	13	6	2	0	0	523	220
7	39	17	11	6	4	1	0	540	320
23	39	18	8	10	2	1	0	615	250
19	40	15	12	7	4	1	1	598	430
32	41	27	9	5	0	0	0	366	280
21	43	25	10	5	2	1	0	234	330
17	44	24	12	4	3	1	0	402	280
16	45	17	14	10	2	1	1	186	350
35	45	22	14	4	4	1	0	496	130

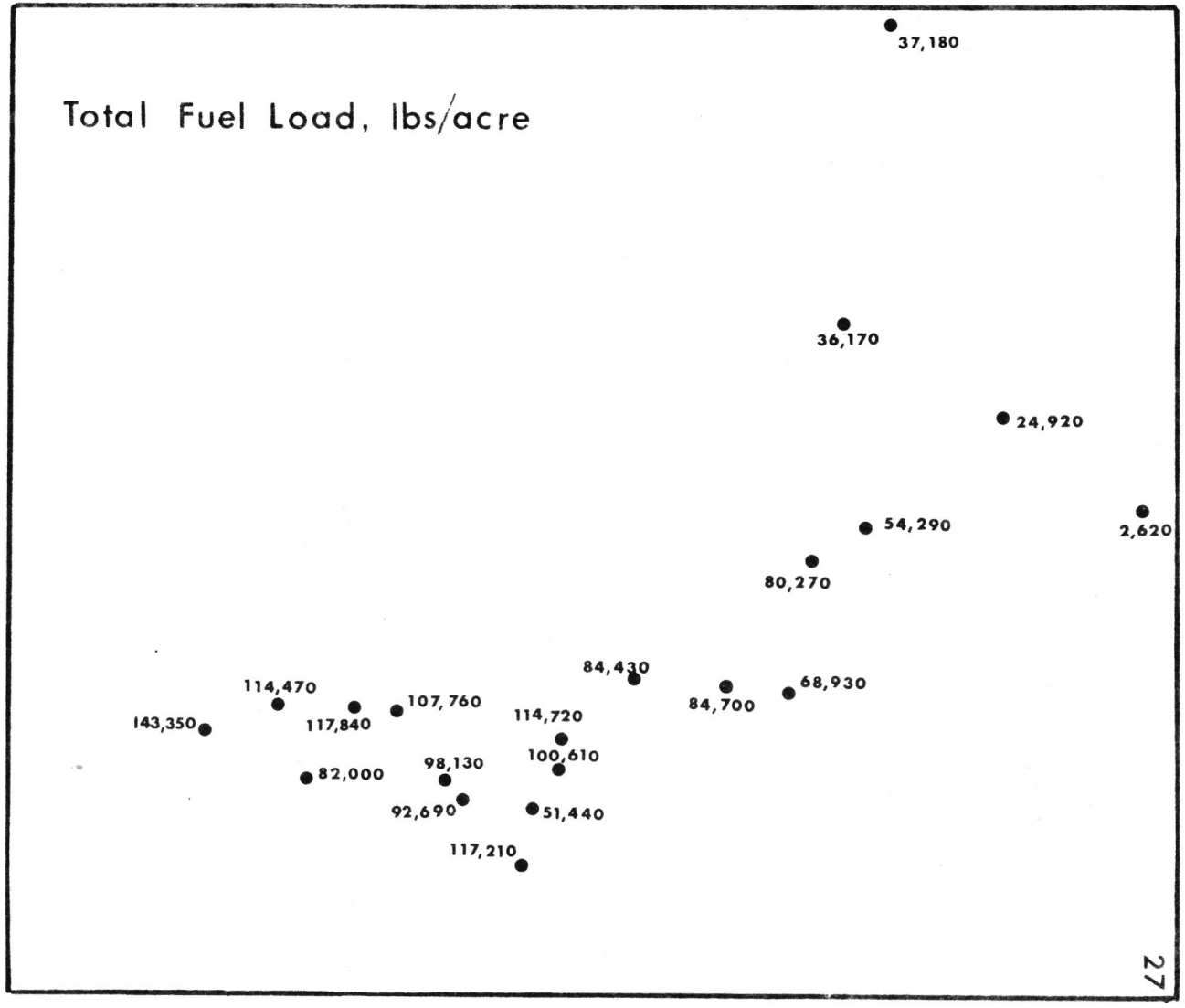
Fuel Measurement Results: A total of twenty stands were sampled for fuel load. Seventeen of these are among the stands previously discussed. Three additional stands were sampled for fuel loadings, but were not analyzed with a 375 m^2 plot. All three of these, as mentioned earlier, occur on dry, upland slopes; the stands are open-canopied; brush and grass species are common. Scattered Pinus ponderosa and Pseudotsuga menziesii make up the cover of two of the three stands, and the third one is dominated by shrubs only. All three stands, however, are considered to be members of the Douglas fir climax series.

Figure 26 represents the fuel measurement stands in the original ordination. The three stands mentioned above were placed within the ordination by empirical means, but based on field notes, and are simply denoted as stands, A, B and C. The stands selected for fuel sampling arrange themselves into all parts of the ordination, although this phase of the research would have been enhanced if all 63 communities could have been analyzed for fuel characteristics.

The fuel components, as mentioned under the "Methods" section of this report, consist of fuel particles of various sizes (diameters) and characteristics. An overall idea of how the organic forest fuels are arranged in these 20 stands, within this ordination, can be attained by an examination of Fig. 27. Here total pounds of organic fuel per acre are plotted. The gradation is not entirely smooth between the moist cedar stands and the drier Douglas fir/ponderosa pine stands, but nevertheless there is a marked reduction in total fuel loads from moist to dry communities. In fact the differences amount to 3-4 fold between the extremes. The differences are perhaps accentuated because the righthand stands are both drier and younger than the stands towards the left side of the ordination.


Fuel Measurement Stands
52
A
B
C
58
54
2
9
1
12
19
15
11
18
21
7
8
6
22
56
26

75a


Total Fuel Load, lbs/acre
37,180
36,170
24,920
54,290
2,620
80,270
84,430
114,470
107,760
68,930
84,700
143,350
117,840
114,720
100,610
98,130
82,000
92,690
51,440
117,210
27

75 b

A breakdown of the fuel subunits is provided in Table 6. Here the twenty stands were segmented into four categories relating to the four basic climax series: (1) Thuja plicata, (2) Thuja-Abies, (3) Abies and (4) Pseudotsuga. The groupings are not equal however; the Thuja plicata climax series is represented by stand 11 only. This stand is an old-aged cedar grove, having trees 50" dbh or larger dominating the stand. The data for each fuel particle size (pounds per acre) have been averaged for the stands in each segment.

The branchwood data are only moderately variable among the four climax series, and the variation that does exist does not appear strongly related to a moist to dry gradient. The lowest quantities of small dimension branchwood occur among the Douglas fir/ponderosa pine stands, whereas the highest value for the 1.6-10.0 cm branchwood occurs in the cedar grove stand. Only one stand among ten averaged for the Thuja-Abies segment (2) exceeded the 4,076 pound value for stand 11.

Branchwood fuels over 10.0 cm in size (including both sound and rotten material of this size) are definitely higher in the cedar grove community than in other climax types, and there does appear to be a gradational reduction in these data from moist sites to dry ones. When the data for rotten (decomposed partially) branchwood over 10.0 cm is examined, we again see a pronounced shift from the moist sites to the more xeric ones. Here stand age no doubt plays an important part. Nearly all of the larger-sized branchwood in the Douglas fir/pine stands is of recent origin... nearly all of it is in a sound condition. More than half of the larger branchwood fuels in thecedar grove stand are in a rotten condition. In the latter stand there have been many years for these fuels to accumulate, but the moist conditions and long time period has allowed considerable decomposition to take place.

Table 6. A summary of forest fuel measurements within the 20 sample stands. The data are averaged for each of four climax forest series: (1) Thuja plicata, (2) Thuja plicata-Abies grandis, (3) Abies grandis, & (4) Pseudotsuga menziesii. The partition of sample stands also relates to their position within the two-dimensional ordination. Values= lbs/acre.

Fuel Feature	Climax Forest Series			
	1	2	3	4
Branchwood Fuels:				
0-0.5 cm diameter	301	430	309	145
0.5-1.6 cm diameter	382	367	288	457
1.6-10.0 cm diameter	4076	2379	2272	3148
10.0 cm+ Branchwood Sound + Rotten	24,056	15,535	10,598	10,140
10.0 cm+ Branchwood Rotten only	14,431	11,290	6,493	260
Litter	144	418	647	917
Grass-forb Fuels	89	102	155	221
Dead Grass-forbs	2	3	9	32
Fine Fuels	829	1,218	1,252	1,473
Total 0-10 cm fuels	4,905	3,721	3,757	4,685
Duff Fuels	114,390	80,414	60,145	8,338
Average Total Load	143,350	89,875	74,525	25,220
Green Fuel Depth (cm)	13	21	43	26
Dead Fuel Depth (cm)	11	24	26	15
Litter Depth (cm)	1.4	1.4	1.6	1.5
Duff Depth (cm)	6.7	4.6	3.3	0.8

In comparing segments 2 and 3 (Thuja-Abies series, and Abies series) it can be noted that significant differences exist in the fuel loadings of the 10.0 cm+ branchwood, but the two series have similar proportions or ratios of sound to rotten.

Litter weights change markedly between the moist and dry/young stands; the dry/young communities have 6-7 times as much litter as the cedar grove. Litter, it should be recalled, is a fuel category that includes all of the material laying on the ground except branchwood greater than 1.6 cm in diameter, cones, grasses and forbs. The litter category does include the needles, bark flakes, brush leaves and other small pieces of debris. The production of litter material is at a minimum in the old-aged, climax cedar grove, but is produced in great quantities in the more open Douglas fir/ pine stands; the highest value recorded for litter occurs in stand 52.... 1970 pounds per acre.

Grass-forb fuels, both living and dead categories, are least abundant in the cedar grove, with stand averages showing increases through the three other climax series. The variations here probably relate to tree densities; the heavily shaded understories of the older cedar and cedar-grand fir communities do not permit the production of dense understory layers; the opposite is true in the Abies and Pseudotsuga types, especially those that are very open-crowned.

The fine fuel category is generally a summation of other small-dimension fuels: 0-.5 cm branchwood, .5-1.6 cm branchwood, litter and dead grass-forbs. Due to rounding off of values and averaging the totals will only be approximate. The fine fuels nearly double between the moist cedar grove community and the drier communities. The reasons are the same as given above.

The total 0-10.0 cm diameter fuels include the 1.6-10.0 cm branchwood material and the total fine fuels. The values in the table for the total 0-10 cm fuels are only approximate summations because of the averaging process. There is variation in these 0-10 cm totals, but the pattern is similar to that for the 1.6-10.0 cm branchwood data. The moist cedar grove and the drier Douglas fir/pine stands have similar totals of 0-10 cm material, but as was seen elsewhere in Table 6 the components of this 0-10 cm value are different in each case; the cedar stand exhibits higher 1.6-10 cm loads, while the drier stands have higher fine fuel values.

Duff fuels are the organic materials extending from the top of the F (fermentation) layer, down to mineral soil (the bottom of the litter layer was defined as the top of the F layer). The duff makes up a large part of the total fuel measured. As can be seen in Table 6 these data form the steepest gradient of change between the cedar grove site and the drier/younger stands. The difference is over one-hundred fold, and certainly it is the duff data that contributes to the changes seen in the overall total load of organic fuels. The duff weights are very well related to the average duff depth data at the bottom of Table 6 No other stand comes anywhere near the duff depth or duff weight exhibited by the redcedar grove.

Fuel depth is defined as the vertical distance from the ground to the highest fuel particle intersecting a circle with its center as the vertical projection from a point on the ground, and a radius of 5 cm (Brown 1971). The depth measurements were made for both dead and living vegetation. Both the green fuel depths and the dead fuel

depths were least in the redcedar grove, and averaged highest in the Abies grandis in segments 3 and 4. These differences are related to the well developed shrub layers existing in the understories of the Abies grandis and Pseudotsuga menziesii community types. This is verified by the coverage values in Table 3; the drier segments of the compositional gradient (segments 4, 5 and 6) exhibit high cover values for such shrubs as Symphoricarpos albus, Holodiscus discolor, Spiraea betulifolia, Philadelphus lewisii and Rosa gymnocarpa. The Thuja and Thuja-Abies stands (gradient segments 1 and 2) have well developed herb layers very often, but poorly developed shrub layers.

Litter depths (Table 6) are nearly identical in all four of the climax series types. All twenty stand measurements fall between 0.8 cm and 3.3 cm. Variation does exist, but the segment averages are much the same. Thus the depth of the litter layer (measured down to the top of the F layer) remains relatively constant in these stands, and apparently independent of habitat moisture and general stand type.

All of the data averaged in Table 6 are the resultant of combining values that vary within each of the four segments; the variation, however, is much like that seen in Fig. 27 for total organic fuel load. The gradational trends in these values are discernable when plotted in the ordination. The intra-segmental variation is important when examining the data for relationships between forest succession and fuel accumulations. This is what will be presented and discussed next.

Forest Development and Fuel Measurements: It has been pointed out and illustrated several times that the ordination that was developed for these wilderness communities emphasizes compositional changes that are

closely related to a moisture gradient; trees, shrubs and herbaceous species display patterns within the ordination that support this view. The averages of the various fuel components (Table 6) reveal that these too are well related to the over-all moisture gradient. It is of fundamental importance too to discover what sorts of relationships exist between forest successional processes and accumulations of organic fuels. It has been clearly pointed out in earlier sections of this report that examples of communities representative of all successional stages, within each climax series, or habitat type, do not really exist in great numbers in all areas of the drainages studied. A century old streamside community can be viewed as relatively "young" when compared to the ages of other streamside stands. The upland forest communities on the Moose Creek drainage are indeed a mosaic of pioneer, seral and old-aged stands. Areas burned in the period between 1910 and 1934 on the adjacent uplands are no substitute for the absence or near absence of such burned areas along the streams.

Inspite of these limitations, an effort was made to provide some interpretation of fuel loadings in stands of different ages within each of the general climax series (roughly approximating the arrangement as developed in Table 6). The limited number of stands (20 fuel samples) does not permit an elaborate time-gradient analysis, but a simple direct one was possible. The results of this attempt are summarized in Table 7

Table 7 is partitioned into five sections. Each section contains the data from several stands that have been ordered from "young" to "old" age. The ordering is based partially on field notes and partially on an interpretation of diameter size classes distributions of the dominant species. The same fuel characteristics are included in Table 7 as were listed in Table 6.

In Table 7-A, the data presented are from four stands occurring in the same portion of the Moose Creek region (stands 54, 15, 12 and 11). Stand 54 was burned by the 1910 fire, and is currently dominated by a mixture of Douglas fir and lodgepole pine, with some grand fir. This young stand, it can be noted in the earlier ordination figures, is positioned among the Abies-Pseudotsuga stands and not among the Thuja/Thuja-Abies stands as are stands 15, 12 and 11. This is a case, and one of only a few, of a seral stand being significantly displaced in the ordination because of the stand composition at this early developmental stage is still similar to forests of drier habitat types. It is perhaps inappropriate to classify this stand to a definite habitat type, but field inspection suggests that it will possess Thuja plicata eventually.

The fuel loads in all four of these stands are high in comparison with young & old stands composing drier community/habitat types. Even stand 54 (with over 80,000 lbs/acre) is rather high. The four stands exhibit accumulations in nearly all fuel categories. Stand 12 is contiguous to stand 11, but experienced a ground fire during the last century. In all four stands the fuels 10.0+ cm in size, in a rotten condition, make up 50% or more of fuels in this class. Stand 54 does not have sound material in this category; all is in advanced decomposition, and very likely all dates back to unburned trees left after the 1910 fire. The current basal area of stand 54 further reflects its relative youth.

In Table 7-B a series of four stands occupying somewhat less moist habitats are arranged in successional order. These are considered members of the Thuja-Abies climax series, but may not be ecologically far-removed from the first set of stands. Stands 8, 6, 19 and 56 occur in the same general vicinity within the ordination and on the

wilderness landscape itself. The four stands in Table 7-B show some gradational change along the scale from left to right, but the changes are less regular and less uniform than seen in the first set of stands. This is because none of the four stands is very young or very old... all are of intermediate age, although not the same age. All four have high coverage values for cedar and/or grand fir. Nevertheless, branchwood fuels, fuels 10.0+ cm., and duff layer fuels show a similar incremental change from the youngest to oldest as the stands in 7-A showed; the living and dead grass-forb fuels also show a decrease in both sets of stands. The duff layer weights, except for the cedar grove site (# 11), are generally similar, as aregreen and dead fuel depths and duff layer depths.

Table 7-C includes stands from well-drained benches and slopes above the level of Moose Creek, and in the area surrounding the Moose Creek Ranger Station. These four stands are dominated by Abies grandis and Pseudotsuga menziesii; Thuja is absent in three of the stands, and one stand has only a trace occurrence of redcedar (below 4" dbh). The variation in the sites represented by these four stands is greater than among the other sets discussed; this is due to the fact that the drier community types were not emphasized in the study and thus undersampled as a rule. The stand ordination makes this very evident.

The data in Table 7-C are conspicuously different from those in 7-A and 7-B. Total organic fuel is half as much or less. A major reason for this is the reduced amount of duff layer fuels. In most cases, also, the green and dead fuel depths are greater in these drier and young stands. Both stands "B" and 58 are recovering from fires that occurred within the past forty years, and it should be noted that in both of these stands the

bulk of the 10.0+ cm fuel material is in the rotten category. In fact, stand "B" has the second highest total for 1.6-10.0 cm branchwood fuels, and highest for the 0.5-1.6 cm fuels.

Table 7-D is composed of data from three dry upland stands that are currently covered by thin covers of Douglas fir and ponderosa pine. Stands "C" and "A" are both in areas that were affected by the 1934 fire that occurred west of the confluence of Moose Creek and the Selway River. Stand 52 currently has the appearance of of an open pine savannah. The basal areas for "C" and "A" are only estimates since a plot tally was not made in these.

Stand "C" has very little branchwood material, and what does exist occurs in the smallest diameter classes. This would reflect the fact that the 1934 fire burned cleanly through this particular area, leaving no standing dead or downed material. Stand "A" does have abundance of sound 10.0+ cm material (none in the rotten stage), reflecting incomplete burning in 1934, and also revealing the fact that decay since 1934 has been slow on this site. This also seems true of stand 52, but this latter area was not burned in 1934.

The savannah-like stand 52 has the greatest quantities of grass-forb fuels, fine fuels, 0-10 cm fuels and duff layer fuels. Agropyron spicatum is common in the understory, and the pine's needles have accumulated on the forest floor. The litter depth and duff layer depth much exceed those in stands "C" and "A". Bracken fern (Pteridium) is also common in stand 52; this species contributes, annually, great amounts of fuel to the fuel bed. There is evidence that stand 52 ought to be classed within the Pinus ponderosa climax series, rather than the Pseudotsuga series. The three stands in Table 7-D probably should not be viewed as being ordered successionally in this table, but

simply as three examples of upland communities.

It is instructive to compare these three dry/young stands with the stands listed elsewhere in Table 7... the older stands occurring on far more mesic and moist sites. Certainly the magnitudes of fuel accumulations are very great between the extreme stands. There exists a 3-4 fold difference between the Thuja-Abies stands of old age and the younger Pinus-Pseudotsuga stands. The reasons for these differences in total organic fuel loadings must be found by examining the various fuel components that contribute to the total. It seem obvious that the major factor is duff layer depths and weights, with 10.0+ cm fuels also of importance.

Table 7-E lists all of the remaining stands from which fuel loading data were collected. These are from various locations and are not ordered in any special way in the table, and are not intended to be related to each other. Stand 21 and 22 are both north-slope forest communities located above the Selway River, and in the vicinity of Tony Creek. Stand 21 is near the slope base and stand 22 occurs at a mid-slope position. Both of these stands occur near one another in the stand ordination (within the Thuja-Abies climax series, but 22 is less mesic than 21). These two stands are nearly identical in all fuel features but one... duff depth and duff weights; litter shows differences too. Both stands are about 150 years old, and probably originated at the time. The differences in fuel loading are probably the result of site environmental factors that are correlated with slope position.

Stands 7 and 18 could probably have both been positioned in Table 7-B; there was uncertainty about the successional status of these, although both are old-aged. Stand 2 relates best to the stands in Table 7-C,

Table 7. A summary of fuel loading data for several sets of stands that represent successional gradients among climax series categories. The stands in each set have been arranged to reflect stand age and development.

A. Thuja plicata/Thuja-Abies communities in vicinity of confluence of East and North Moose Creeks (see Fig. 1): Values = lbs/acre.

Fuel Characteristics	Stand Numbers			
	54	15	12	11
Branchwood: 0-.5 cm	185	398	390	301
.5-1.6 cm	134	324	363	382
1.6-10.0 cm	1,852	1,482	2,583	4,076
10.0+ cm, sound & rotten	5,939	20,688	16,072	24,056
10.0+ cm, rotten only	5,939	14,896	10,319	14,431
Litter layer	530	277	234	144
Grass-forb, live & dead	159	191	75	89
Grass-forb, dead only	4	5	2	2
Fine fuels	854	1,005	990	829
Total 0-10 cm fuels	2,904	3,281	3,583	4,905
Duff layer	71,428	83,795	94,812	114,393
Total organic load	80,273	107,765	114,467	143,354
Green fuel depth (cm)	20	18	4	13
Dead fuel depth (cm)	11	5	4	11
Litter layer depth (cm)	1.5	1.2	2.2	1.4
Duff layer depth (cm)	4.2	4.9	5.6	6.7
Basal area (ft^2/acre)	41	339	610	675

Table 7-A (continued)

Fuel Characteristics	Stand Numbers 54	15	12	11
A. Branchwood: 10+cm S+R Standard Deviations:	10,325	24,880	22,930	27,060
Percent Error	55%	38%	45%	35%
B. Total 0-10 cm fuels				
Standard Deviations	2,605	4,605	4,755	5,620
Percent Error	28%	44%	42%	36%
C. Total Fuel Load				
Standard Deviations	65,365	47,200	35,145	81,265
Percent Error	26%	14%	10%	18%
D. Number of Plots	10	10	10	10

Table 7 (continued)

B. Thuja-Abies communities in vicinity of Vista Creek just north of the Moose Creek Ranger Station (Fig. 1): Values = lbs/acre:

Fuel Characteristics	Stand Numbers			
	8	6	19	56
Branchwood 0-.5 cm	380	417	454	557
.5-1.6 cm	267	268	345	447
1.6-10.0 cm	741	1,730	1,487	3,409
10.0+ cm sound & rotten	21,020	8,980	22,265	18,930
10.0+ cm, rotten only	17,020	6,750	20,260	11,933
Litter layer	233	378	423	287
Grass-forb, live & dead	160	135	66	58
Grass-forb, dead only	4	3	2	1
Fine fuels	885	1,065	1,225	1,295
Total 0-10 cm fuels	1,625	2,800	2,710	4,700
Duff layer	74,850	80,890	93,060	94,310
Total organic load	98,127	92,685	117,840	117,210
Green fuel depth (cm)	19	27	16	13
Dead fuel depth (cm)	7	10	5	10
Litter depth (cm)	1.2	1.2	1.5	1.5
Duff layer depth	4.4	4.7	5.4	5.4
Basal area (ft^2/acre)	360	540	598	320

Table 7-B (continued)

Fuel Characteristics	Stand Numbers 8	6	19	56
A. Branchwood 10+ cm S+R				
Standard Deviation	21,355	28,310	49,340	32,380
Percent Error	31%	81%	100%	56%
B. Total 0-10 cm fuels				
Standard Deviations	1,795	3,000	1,960	3,890
Percent Error	35%	27%	32%	26%
C. Total Fuel load				
Standard Deviations	47,095	65,510	94,395	40,990
Percent Error	15%	18%	36%	11%
D. Number of Plots	10	10	10	10

Table 7 (continued)

C. Abies grandis/Pseudotsuga communities in the vicinity of the Moose Creek Ranger Station, upland, well-drained benches and slopes.

Fuel Characteristics	Stand Numbers			
	"B"	58	1	9
Branchwood: 0-.5 cm	401	235	255	126
.5-1.6 cm	724	267	252	333
1.6-10.0 cm	6,515	1,600	1,505	3,200
10.0+ cm, Sound & Rotten	1,035	5,725	4,010	12,750
10.0+ cm Rotten only	1,035	5,035	497	5,950
Litter layer	103	233	379	911
Grass-forb, live & dead	113	306	140	120
Grass-forb, dead only	3	21	6	11
Fine fuels	1,230	755	891	1,380
Total 0-10 cm fuels	7,745	2,360	2,395	5,070
Duff layer	16,115	46,305	62,515	66,540
Total organic load	24,915	54,290	68,930	84,705
Green fuel depth (cm)	49	130	20	37
Dead fuel depth (cm)	31	86	14	14
Litter depth (cm)	1.1	1.4	1.6	3.1
Duff layer depth (cm)	0.7	2.5	3.6	3.1
Basal area (ft^2/acre)	0	39	240	297

Table 7-C (continued)

Fuel Characteristics	Stand Numbers "B"	58	1	9
A. Branchwood: 10+cm S+R				
Standard Deviations	2,285	13,105	11,020	27,018
Percent Error	98%	72%	87%	67%
B. Total 0-10 cm fuels:				
Standard Deviations	4,245	2,140	2,995	8,660
Percent Error	24%	29%	39%	54%
C. Total Fuel load:				
Standard Deviations	3,195	27,210	49,765	45,170
Percent Error	6%	16%	23%	17%
D. Number of Plots	10	10	10	10

Table 7 (continued)

D. Pseudotsuga menziesii/Pinus ponderosa community types in the vicinity of the Moose Creek Ranger Station; upland slopes on warm exposures.

Fuel characteristics	Stand Numbers		
	"C"	"A"	52
Branchwood: 0-.5 cm	58	91	32
.5-1.6 cm	22	95	987
1.6-10.0 cm	0	3,330	2,748
10.0+ cm Sound & Rotten	0	25,310	14,215
10.0+ cm, Rotten only	0	0	0
Litter layer	600	1,080	1,970
Grass-forb, live & dead	235	130	410
Grass-forb, dead only	40	26	61
Fine fuels	720	1,290	2,645
Total 0-10 cm fuels	720	4,880	5,395
Duff layer	1,975	6,005	17,628
Total organic fuel load	2,620	36,167	37,180
Green fuel depth (cm)	12	24	19
Dead fuel depth (cm)	5	17	8
Litter depth (cm)	0.9	1.0	3.3
Duff layer depth (cm)	0.25	0.27	2.0
Basal area (ft^2/acre)	55	69	147

Table 7-D (continued)

Fuel Characteristics	Stand Numbers "C"	"A"	52
A. Branchwood: 10+cm, S+R			
Standard Deviations	0	57,590	21,355
Percent Error	0	72%	67%
B. Total 0-10 cm load:			
Standard Deviations	472	7,750	4,000
Percent Error	20%	50%	33%
C. Total Fuel load:			
Standard Deviations	3,820	59,725	29,295
Percent Error	46%	52%	35%
D. Number of Plots:	10	10	5

Table 7 (continued)

E. Other stand data: the five stands below were not employed in the earlier "successional gradients" (Parts A-D). Stands 21 and 22 are North-slope samples composed of Abies, Thuja and Pseudotsuga;stands 7 and 18 are Thuja-Abies on streamside sites and stand 2 is an Abies grandis stand on a well drained bench above Moose Creek, west of runway.

Fuel Characteristics	Stand Numbers				
	21	22	7	18	2
Branchwood: 0-.5 cm	349	353	449	560	744
.5-1.6 cm	450	357	420	425	454
1.6-10.0 cm	1,985	2,870	740	6,755	3,205
10.0+ cm, S & R	10,670	10,665	5,625	20,645	24,565
10.0+ rotten only	8,700	8,280	0	14,745	15,015
Litter layer	688	259	779	619	1,180
Grass-forb;all	129	63	88	59	51
Grass-forb: dead	3	3	2	2	1
Fine fuels	1,490	973	1,650	1.605	2,380
Total 0-10 fuels	3,477	4,280	2,390	8,360	6,055
Duff layer	86,220	36,525	73,980	85,690	53,935
Total load	100,615	51,445	82,000	114,720	84,435
Green fuel depth	28	69	18	7	7
Dead fuel depth	9	57	2	12	3
Litter depth	1.3	1.3	1.4	1.0	0.8
Duff depth	4.8	1.6	4.3	5.0	3.1

Table 7-E (continued)

Fuel Characteristics	Stand Numbers				
	21	22	7	18	2
A. Branchwood 10+cm					
Standard Deviations	15,235	10,725	12,580	15,745	44,200
Percent Error	45%	29%	100%	24%	49%
B. Total 0-10 cm Fuels:					
Standard Deviations	3,010	4,090	1,650	5,335	4,865
Percent Error	27%	27%	31%	16%	22%
C. Total Fuel load:					
Standard Deviations	37,555	17,730	52,040	29,520	56,100
Percent Error	12%	10%	28%	8%	18%
D. Number of Plots:	10	10	5	10	13

Table 8. Shrub fuel loadings. The values given are pounds per acre.*

Species	Stands							
	22	B	9	A	6	54	C	21
Total all species	8178	1146	783	576	552	532	365	198
Amelanchier alnifolia	543	255	0	306	407	117	340	16
Rosa gymnocarpa	32	0	7	21	3	8	3	40
Symphoricarpos albus	56	0	190	10	107	31	10	12
Spiraea betulifolia	111	60	52	14	19	29	3	48
Lonicera utahensis	5	0	0	0	0	141	0	4
Berberis repens	0	61	0	226	0	98	10	2
Vaccinium membranceum	91	353	15	0	0	0	0	60
Physocarpus malvaceus	5902	254	519	0	0	29	0	0
Rubus parviflorus	78	52	0	0	0	0	0	12
Alnus spp.	0	0	0	0	11	0	0	4
Holodiscus discolor	485	0	0	0	0	0	0	0
Vaccinium caespitosum	0	0	0	0	0	79	0	0
Ceanothus spp.	0	110	0	0	0	0	0	0
Menziesia ferruginea	0	0	0	0	0	0	0	0
Sorbus spp.	0	0	0	0	0	0	0	0
Acer glabrum	875	0	0	0	0	0	0	0
Crataegus douglasii	0	0	0	0	6	0	0	0

* Stands 11, 12, and 52 lacked shrubs in the fuel measurement plots.

Table 8 (continued)

Species	Stands						
	15	58	56	8	7	2	19
Total all species	166	132	122	117	116	81	78
Amelanchier alnifolia	24	6	0	33	32	5	0
Rosa gymnocarpa	45	0	9	6	28	5	0
Symphoricarpos albus	0	0	43	24	39	22	0
Spiraea betulifolia	14	60	7	5	0	31	25
Lonicera utahensis	30	0	17	38	8	12	4
Berberis repens	14	4	4	4	0	0	0
Vaccinium membranaceum	8	17	0	7	2	0	44
Physocarpus malvaceus	0	0	0	0	0	6	0
Rubus parviflorus	2	45	2	0	0	0	0
Alnus spp.	7	0	0	0	7	0	0
Holodiscus discolor	0	0	40	0	0	0	0
Vaccinium caespitosum	16	0	0	0	0	0	0
Ceanothus spp.	0	0	0	0	0	0	0
Menziesia ferruginea	0	0	0	0	0	0	5
Sorbus spp.	6	0	0	0	0	0	0
Acer glabrum	0	0	0	0	0	0	0
Crataegus douglasii	0	0	0	0	0	0	0

but I was reluctant to include it as a member of the forest successional gradient in Table 7-C. It seems evident that further field data from other communities composed of Abies grandis and Pseudotsuga are required to improve this phase of the analysis.

A good impression of the precision associated with the fuel loading values can be obtained by examining the second halves of each of the sub-tables (7-A to 7-E). The standard deviations and percent errors are given for each stand for branchwood 10+cm (sound + rotten), total 0-10cm fuels and total fuel load. Many of the standard deviations are large in all fuel characteristics listed. Much of this is thought to be due to the spatial arrangement of the fuels in the stands sampled. The larger branchwood fuels are not uniformly distributed in the understory (as the smaller fuel particles often are) and the ten-plot samples (only 5 plots in stands 7 and 52) may have been too few. However, even 20-plot samples, taken in a fuel study in Glacier National Park (Lunan 1972), yielded similar magnitudes of deviations in the larger fuel classes.

Summary Remarks Concerning Fuel Accumulations: The results reveal that fuel loadings are well correlated with site moisture. The heaviest fuel accumulations presently occur in the old-aged, streamside forests dominated by Thuja plicata and Abies grandis. Much of the total measured fuel material is duff. Duff layers are deepest in the oldest cedar/grand fir stands and least in the drier upland Douglas fir/ponderosa pine stands. The streamside communities have mostly escaped highly destructive fires for many years, although evidence exists that ground fires and non-spreading spot fires have visited these old stands in the past. The depth of the duff layer is thought to be related to fire periodicity. Litter layer

depths are nearly identical, on the average, among the the twenty stands sampled, but litter weights are much higher in the drier Douglas fir/ponderosa pine stands than in the cedar/grand fir stands. Litter is produced at lower rates in the streamside stands, but the much longer periods between fires on such sites allows for the greater accumulation (depth and weight) of duff fuels. During the past several centuries the upland forest sites have experienced a greater frequency of fire and consequently these stands have duff layers that average less than one (1.0) centimeter in depth (Table 6).

Analysis of Fire Potential: Predictions of fire potential in the twenty stands were made utilizing the mathematic and computer models developed and discussed by Rothermel (1972) and Brown (1972). Dr. James K. Brown, of the Northern Forest Fire Laboratory, Missoula (USDA Forest Service) is greatly acknowledged for his efforts in these data computations.

Two values were determined: reaction intensity (I_R) and rate of fire spread. Reaction intensity is a measure of energy release expressed in B.t.u.'s per square foot per minute for a cross section of the flame front. Reaction intensity is considered to be one of the best measures to employ in comparing fire potentials between different communities. The fuel data were analyzed at an assumed 5.0% fuel moisture content, and site slope was set at 0^{o}. Rate of spread values were calculated both at an assumed wind of 2 mph and 10 mph. A summary of these data is presented in Table 9. Average aspect and average slope (degrees), and a brief stand type title are also included in this table. The stands in this table are arranged from lowest to highest reaction intensities.

In general, the moist, streamside stands... old-aged and dominated

Table 9. A summary of reaction intensties (BTU's/ft.^{2}/minute) and rates of fire spread (feet/minute) for the twenty stand samples. Calculations were based on a standarized 5.0% fuel moisture content; slope conditions were standardized at 0^o, and values were calculated for both a projected 2 mph and 10 mph wind. The stands are arranged from lowest to highest reaction intensities.

Stand Number	Average Aspect	Average Slope	Reaction Intensity	Rate of Spread 2 mph	Rate of Spread 10 mph	Stand Type
58	306	40	54	9	38	Young pioneer
8	270	3	148	0.7	4	Old Thuja/Abies
22	40	86	169	5	25	D. fir-G. fir-cedar
1	290	17	190	1	7	G.fir-D. fir
15	120	3	202	0.4	2	Cedar-G. fir
6	243	5	237	0.8	5	G.fir-cedar
19	130	9	257	0.4	2	Cedar-G. fir
12	270	0	260	0.2	1	Cedar grove
"C"	270	47	271	2	15	P.pine-D. fir
54	180	1	282	1	7	D. fir-lodgepole
7	310	1	312	0.2	1	Cedar
2	332	22	354	0.2	1	Grand fir-D. fir
56	130	21	361	0.7	3	Cedar-G. fir
21	40	34	368	0.8	5	Cedar-G. fir
11	270	2	443	1	5	Cedar grove
"B"	90	77	602	4	14	Brushfield
"A"	124	80	615	2	14	P. pine-D. fir
18	100	16	697	1	4	Cedar-G. fir
52	164	72	1043	1	7	P.pine-bracken

by Thuja plicata and Abies grandis... have the lowest predicted fire spread rates and low to intermediate reaction intensities, whereas the younger, Douglas fir and ponderosa pine stands located on upland sites have higher spread rates and somewhat higher reaction intensities. This generalization is supported by plotting these data in the stand ordination such as was presented in Fig. 26, page Exceptions to these conclusions exist. Stand 58 does have a high spread rate as do the other drier community types (stands "A", "B" and "C" for example) but the reaction intensity (54 B.t.u./ft^2-min) is much lower than these other stands.

The older streamside stands (segment 1 in Table 6) have heavier fuel loads in the larger diameter classes, and much of this is in the rotten category. The upland community samples (segment 4 in Table 6) have greater quantities of litter and grass-forb fuels. These same stands have well developed shrub layers (Segments 5 and 6 in Table 3;Table 8) whereas the more moist, bottomland cedar stands have very poorly developed shrub layers. Even with a 10 mph wind the predicted rate of fir spread is very small in these moist communities.

The rates of spread in Table are based on 0^o slopes; it is noted however that the actual slopes involved for the upland samples are rather steep in many cases. The actual rates of spread would be much higher than indicated in stands 22, "A", "B" and 52 because of the slope steepness. Such differences in rates of spread were described in the White Cap Report (Aldrich and Mutch 1972) when 0^o slope rates were compared with rates based on actual slope degrees.

The data presented for these 20 stands no doubt represent the range of values that currently exist in the vegetation mosaic surrounding the lower portion of Moose Creek. The variation measured is thought to be

due to variations in site moisture, vegetation development and past fire activity in each of the stands sampled. Our understandings of reaction intensities and rates of spread are not well developed however for certain community types or developmental stages. This has been mentioned earlier. The lack of pioneer stages in streamside habitats, and lack of intact old aged upland communities prevent me from arriving at a description of fire potential changes over time within a given forest climax series. A gradient of change from younger, upland stands to older-aged lowland communities is not a meaningful successional gradient. The data we now have from the Moose Creek area does help to explain why the moist cedar communities have not burned for many centuries, or at best supported only occasional ground fires, and why these streamside stands may not burn in the near future. We also have a better idea of the reasons why climax upland stands are so rare.

Fire and Landscape Patternization

The description, measurement and interpretation of landscape patterns are important in many kinds of phytosociological studies. The arrangement of forest communities on the Selway-Bitterroot Wilderness landscape has been of importance in these current studies. Communities are, in simple terms, assemblages of species populations occurring together and interacting together in a given habitat. Each plant species is thought to have individualistic, ecological behavior; no two species generally display identical amplitudes of environmental tolerance. But there is also evidence that plant species composing plant communities have co-evolved together, and many species found growing together, with regularity, have become adapted

to similar sets of environmental conditions. The diverse topography in this wilderness has produced an environmental complex that is highly variable. The moisture and temperature gradients that exist within the wilderness boundaries adds to this complexity. The differential range limits of the plant species within this wilderness also effects the ecological situation. If every acre in the Selway-Bitterroot Wilderness was currently supporting mature, climax ecosystems, the landscape patterns would be still be a complex problem worthy of phytosociological investigation.

In reality, we must superimpose upon the complexity caused by topoclimatic factors, the influence of fire. Fire is an environmental factor. Fire is a decomposer agent too. Fire has been and continues to be a significant force in the evolution of floras and faunas. In the Selway-Bitterroot Wilderness, fire has been a major influence on landscape patternization. There is no reason to doubt that fire has been an influence in this region as long as any other environmental factor.

When examining maps that illustrate the occurrence and extensiveness of past recorded fire, one is certainly impressed by the proportion of the total wilderness that has been burned during the past century. When one has the opportunity to examine the wilderness from an aerial view, it seems evident that the landscape not only reflects the last century's worth of fires, but the fires of the past 200 or 300 years... or more. On aerial flights, one can note that regions purportedly burned in a given year, such as 1910 or 1934, and colored uniformly on a fire map, are often composed of a crazy-quilt pattern of plant communities in various

stages of successional recovery. A "burned over" area is rarely burned in a precisely uniform way. No two acres are likely to be affected in exactly the same way. The differential survival and mortality of plants in a "burned over" area play important roles in the subsequent landscape patterns that become the subject of intensive field investigations. Forest succession following fire becomes a series of plays within a play. As we have mentioned earlier in this report topography and moisture play critical roles in forest community compositions; these same factors effect the rates of biomass production within different communities; they also influence the periodicity of fire. The streamside redcedar groves have been only spectators of fires during the past several centuries; the drier upland communities have been active participants in past fire events.

Past fire and a variety of topographic features (position on slope, aspect, elevation, ridgelines, ravines, etc), interacting with one another, have no doubt been the major cause of the upland patternization one witnesses today in the wilderness. One can imagine that the community diversity resulting from fire in turn influences the nature of fire occurring at a later date. Stands 21, 22, 58 and "B" are pattern components occupying the generally north-facing slope above the Selway River near the Moose Creek Ranger Station. Table reveals that these four stands represent a fairly wide range of reaction intensities and rates of spread (I_R's = 54-602 Btu's/ft^2-min., and 5-38 ft/min spread rates at 10 mph). As portions of a hillside mosaic, each must have some relationship to the other, or at least some are related to others. Does it make a difference that stand "B" is only a few acres in size, and surrounded by vegetation of the type

described by the data collected for stand 58? Does it matter that stand 22 is located upslope from stand 21? In the past the various development communities were no doubt in different spatial arrangements and the relative amounts of high or low fuel accumulations, etc., were different than they are now. The kaleidoscope effect on the landscape is a realistic viewpoint; on some habitats a "turn" is made every 50 or 100 years, elsewhere the pattern is changed only infrequently.

An examination of aerial photos gives us some idea of changes that can and do take place during a period of 35 years. Photos taken in the late 1930's and again in 1970 allow a comparison to be made of areas in the Moose Creek area. The area west of the Moose Creek Ranger Station, and occupying much of the area westward to Selway Falls, was burned in 1934. The fire, was partially destructive to the Douglas fir and ponderosa pine covering the south-facing slopes; in many areas the fire evidently remained on the ground, and functioned only in thinning the forests. The crowns of individual trees are seen on the older photos, giving the appear of open savanna vegetation.

In 1970 photo coverage, it can be noted that forest establishment and development had occur within the ravines and on the more mesic aspects; the warmer southwest-facing slopes still had nearly the same general appearance as in the earlier photos. In a similar way, areas that appear as "openings" on the north slope above the Selway River on the earlier photos, now reveal themselves as nearly "closed." Comparison of streamside areas in each photo set reveals no discernable changes.

So, moisture and topographic features do effect landscape patterns when operating in conjunction with fire. In the complete absence of fire landscape diversity would still exist; the various conifer species, each with its individualistic behavior, would give rise to compositional

variations. Fire, however, does induce community life-form variability on the wilderness landscape. The reduction of fire, or its elimination can lead to a loss in the number of pioneer communities present on the landscape. Many kinds of animal species are more positively associated with certain life-forms of vegetation rather than to the specific composition. If an increasing number of contiguous acres become dominated by a single life-form on this wilderness landscape, particularly upland acres, what does this mean in terms of fire potential in future years? We do not know the answer to this question. It involves something that perhaps we'd rather not test ourselves on anyway. Landscape diversity, which includes species diversity, community diversity and life-form diversity, is the wilderness resource to be perpetuated, and these ought to be the focal points of wilderness management planning. The ecological theory behind this suggestion has been well developed and discussed by Loucks (1970) who published a paper entitled, "Evolution of Diversity, Efficiency and Community Stability." This should be made required reading for wilderness managers.

Conclusions and Summary

The forest communities occurring in the Moose Creek drainage, and adjacent areas, are of interest not only because they are located in the heart of the Selway-Bitterroot Wilderness, but because they seem to be closely related to a regional, climatic tension zone wherein a variety of the major tree species reach their botanical range limits. Although fires in the past have influenced this drainage, the absence of such "classical" fire species as Pinus monticola and Larix occidentalis creates a situation where the remaining species, Thuja plicata, Abies grandis, Pseudotsuga menziesii and Pinus ponderosa, compose both the younger

stands and the older mature stands.

Moisture appears to be the factor of major influence in community compositions and distributions, with fire having a significant modifying effect. Thuja plicata is the major dominant on sites classed as streamside; this tree is common along Moose Creek and its tributaries. It also extends itself to sites that are somewhat elevated (stream terraces and benches) and better drained; it does occupy the lower slope positions on north-facing aspects. Abies grandis is a constant companion of redcedar, but its numbers vary. Grand fir and redcedar are both well represented on benches and lower north slopes. Instances have been recorded of redcedar occurring at elevations well above 4000 feet on northwest-facing slopes. It is possible that Thuja plicata is composed of localized ecotypic subpopulations which account for its total range distribution in the Moose Creek area.

Grand fir can tolerate less mesic conditions than redcedar, and consequently occupies a large total acerage in the Moose Creek drainage. Grand fir occurs jointly with Douglas fir on many of the lower slope positions. The role of Douglas fir, when mixed with grand fir, may be either as a major seral species or as a minor climate associate; in different communities it may well play both roles. Pinus ponderosa seems to function primarily as a seral species in the communities studied; at times a major seral component, and at other times only a minor seral member.

In examining the vegetation in the Moose Creek area, it was soon discovered that fires in the past have not treated the landscape equally. The streamside habitats have burned with much less frequency compared to upland habitats. Basal fire scars on old-aged cedars and grand firs are testimonials to past ground fires even in these moist communities.

Even when one examines the very oldest cedar groves along Moose Creek, one is likely to encounter blacken stumps or charred snags of isolated cedars that became ignited, but the fires causing this showed little propensity to spread elsewhere.

Conversely, an examination of upland terrain yields an abundance of evidence that numerous fires have visted in the past. Old -aged Douglas fir communities are rare. The present-day array of communities did allow a landscape pattern analysis to be made; multidimensional ordination techniques demonstrate that the vegetation varies continuously in space (along moisture gradients); the vegetation also varies continuously in time too, but the lack of young streamside samples, and old-aged upland samples seriously hindered a complete description of successional patterns.

Organic fuel accumulations are well related to moisture and fire patterns. The moist bottomland communities display the highest total weights of fuel; the recently burned upland sites have the smallest current accumulations. Fire potential, however, is greater among the latter stand types than in the former types. The lowland cedar groves have not burned in their entirety as often as the upland forests. The redcedar and grand fir that make up these moist communities display fewer fire adaptations than do species such as Douglas fir and ponderosa pine. In much of the Moose Creek drainage it is probable that ponderosa pine and the communities it forms are actually fire dependent; during a prolonged absence of fire, pine communities are likely to be replaced by Douglas fir. Good examples exist where pine openings are even being invaded by grand fir.

In this report a case is developed that Thuja plicata may be shrinking its range limits within the wilderness area. In cedar-grand fir stands at the lower reaches of Moose Creek and Bear Creek (and the Lochsa River), cedar

is not reproducing itself well. In dense stands, cedar seedlings originating from seed are not common; vegetative reproduction is generally more important. There appears to be "no problem" in this regard in the upper Moose Creek and upper Lochsa River areas where snow depths are great and summers are cool. Cedar may be less capable of reproducing itself on the lower portions of these drainages because of climatic changes that involve less snow and warmer summers; both conditions would reduce the successfulness of vegetative reproduction.

Sexual reproduction of cedar has been noted (in small numbers) along disturbed trail edges, where greater light can penetrate to the ground layer. This has been observed both on the upper and lower portions of these drainages. If "disturbance" and greater light allow sexual reproduction to occur, then a case might be made for explaining cedar's marginal reproductive success in the lower-drainage areas = THUJA PLICATA REQUIRES FIRE IN SUCH AREAS TO ESTABLISH A POPULATION.

If redcedar communities are accepted as a valuable resource in the Selway-Bitterroot Wilderess, then more research should be directed at this species, particularly at its range limits.

Other future research should include: (1) additional study of species and community diversity; (2) an expanded sampling program wherein stages of successional development "missing" in this present analysis can be sought out and studied, (3) the development of some sample contour maps that contain fire potential data (reaction intensities and spread rates); this would be useful in better understanding the role of fire in developing landscape patterns, and how such patterns effect fire behavior.

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FLORA LIST FROM WILDERNESS STUDY AREAS[1]

The species listed below originate from study plots and from general collections made in the wilderness during the summer of 1972:

I. SHRUBS:

Acer glabrum
Amelanchier alnifolia
Ceanothus sanquineus
Ceanothus velutinus
Cornus stolonifera
Crataegus douglasii
Holodiscus discolor
Lonicera involucrata
Lonicera utahensis
Menzeisia ferruginea
Pachistima mysinites
Philadelphus lewisii
Physocarpus malvaceus
Prunus emarginata
Prunus virginiana
Rhamnus alnifolia
Rhamnus purshiana
Ribes irriguum
Ribes Viscosissimum
Rosa gymnocarpa
Rubus idaeus
Rubus leucodermis
Rubus parviflorus
Sambucus racemosa
Sorbus scopulina
Sorbus sitchensis
Spiraea betulifolia
Symphoricarpos albus
Taxus brevifolia
Vaccinium caespitosum
Vaccinium globulare
Vaccinium membranaceum

II. SUBSHRUBS:

Arctostaphylos uva-ursi
Berberis repens
Clematis columbiana
Glossopetalon nevadense
Linnaea borealis
Lonicera ciliosa

III. FERNS AND FERN ALLIES:

Adiantum pedatum
Athyrium filix-femina
Botrychium virginianum
Cryptogramma crispa
Cystopteris fragilis
Dryopteris filix-mas
Equisetum arvense
Equisetum fluviatile
Gymnocarpium dryopteris
Lycopodium annotinum
Lycopodium complanatum
Polystichum munitum
Pteridium aquilinum
Selaginella wallacei
Woodsia oregana

IV. GRAMINOIDS:

Agropyron spicatum
Bromus carinatus
Bromus mollis
Bromus vulgaris
Calamagrostis rubescens
Carex geyeri
Cinna latifolia
Dactylis glomerata
Deschampsia elongata
Festuca idahoensis
Festuca occidentalis
Festuca scabrella
Holcus lanatus
Koeleria cristata
Luzula glabrata
Luzula parviflora
Melica subulata
Poa pratensis
Trisetum canescens

[1] Nomenclature follows Hitchcock, et al., 1955-69. Mr. Peter Stickney USDA Forest Service, is acknowledged for his identification of plant

Wilderness Flora (Continued)

V. FORBS:

Achillea millefolium
Actaea rubra
Acontinum columbianum
Adenocaulon bicolor
Agroseris glauca
Allotropa virgata
Anaphalis margaritaceae
Anemone piperi
Angelica arguta
Antennaria luzuloides
Antennaria racemosa
Apocynum androsaemifolium
Arabis holboellii
Arenaria macrophylla
Arnica cardifolia
Arnica latifolia
Asarum caudatum
Aster conspicuus
Astragalus miser

Balsamorhiza sagittata
Brodiaea douglasii

Calochortus elegans
Calypso bulbosa
Campanula rotundifolia
Castilleja miniata
Chaenactis douglasii
Chmiaphila menzeisii
Chimaphila umbellata
Cicuta douglasii
Circaea alpina
Cirsium arvense
Claytonia lanceolata
Clintonia uniflora
Collomia grandiflora
Collomia linearis
Coptis occidentalis
Corallorhiza maculata
Corallorhiza mertensiana
Cornus canadensis
Cryptantha torreyana

Disporum hookeri
Disporum trachycarpum
Dodecatheon jeffreyi

Eburophyton austinae
Epilobium angustifolium
Epilobium paniculatum
Erigeron divergens
Erigeron speciosus
Erigeron strigosus
Eriogonum heracleoides

Fragaria vesca
Fragaria virginiana

Galium boreale
Galium triflorum
Gernaium viscosissimum
Geum macrophyllum
Gilia aggregata
Goodyera oblongifolia

Habenaria dilatata
Habenaria orbiculata
Hackelia cinerea
Helianthelia uniflora
Heuchera grossularifolia
Hieracium albertinum
Hieracium albiflorum
Hieracium cynoglossoides
Hypericum perforatum

Listera caurina
Listera cordata
Lomatium triternatum
Lotus corniculatus
Lupinus spp.

Madia gracilis
Mentzelia disperma
Microseris nutans
Mimulus guttatus
Mimulus moschatus
Mitella stauropetala
Monotropa uniflora
Montia sibirica

Orobanche uniflora
Orthocarpus tenuifolius
Osmorhiza chilensis
Osmorhiza occidentalis

Wilderness Flora (continued):

Pedicularis racemosa
Penstemon albertinus
Penstemon diphyllus
Penstemon wilcoxii
Phacelia hasata
Phacelia heterophylla
Plantago lanceolata
Potentilla argata
Potentilla glandulosa
Prenanthes sagittata
Prunella vulgaris
Pterospora andromedea
Pyrola aphylla
Pyrola asarifolia
Pyrola picta
Pyrola secunda
Pyrola virens

Ranunculus acris
Rudbeckia occidentlis
Rumex acetosella

Sanguisorba occidentlais
Satureta douglasii
Senecio triangularis
Silene douglasii
Silene menziesii
Smilacina racemosa
Smilacina stellata
Spiranthes romanzoffiana
Streptopus amplexifolius
Synthyris platycarpa

Taraxacum officinale
Thalictrum occidentale
Thermopsis montana
Thlaspi fendleri
Tiarella unifoliata
Tragopogon dubius
Trautvetteria caroliniensis
Trifolium repens
Trillium ovatum

Valeriana sitchensis
Veratrum viride
Vicia americana
Viola adunca
Viola glabella
Viola orbiculata

Xerophyllum tenax

VI. ANNUALS:

Clarkia pulchella
Collinsia parviflora
Galium aparine
Gayophyton nuttallii
Phacelia linearis

VII. TREES:

Abies grandis
Abies lasiocarpa
Betula papyrifera
Larix occidentalis
Picea engelmannii
Pinus contorta
Pinus monticola
Pinus ponderosa
Pseudotsuga menziesii
Thuja plicata